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Edited by J. A. MALLETT

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COVER PICTURE

The Canning Dam, principal source of the Metropolitan water supply, was completed in 1940 and has a capacity of 20,550 million gallons. Taken after heavy rains had caused the dam to overflow, this colour photograph shows the white water forming lace-like patterns on the spillways and cascading over the rocks below

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PRODUCING LUCERNE HAY FOR NORTH-WEST PASTORAL AREAS

By J. A. LAWSON, B.Sc. (Agric.), Agricultural Adviser

ON a great number of our North-West and Kimberley stations, surplus water, which could be used for irrigation, is available in large quantities from river and creek pools and bores. Many station managers have made use of these water supplies to very good effect, and others are keenly interested.

The economics of irrigation should be carefully studied before any project is attempted, and the following points may be of some assistance to those intending to develop such an area in the near future.

1. **How much water will actually be available?** The smaller the supply of water, where pumping is necessitated, the greater will be the cost of production per acre. Remember too that when only a small stream is being pumped, i.e., 3,000 gallons per hour or less, a full working day for one man will be required to irrigate one acre of lucerne.

2. **How much "head" must be overcome by the pump?** Consult a good pump table such as put out by the pump manufacturers, and after calculating total "head" to be overcome, determine what type and size of pumping plant would be necessary to deliver adequate water. This is often a limiting factor. If the supply is located in a bore at considerable depth, a vertical spindle pump must be used and this will involve further cost.

3. **How long will the supply last?** River pools can be most deceptive in so far as their capacity is concerned, and accurate assessment of this is almost impossible. However a good approximation is given by the following formula:—

Approx. surface area (sq. ft.) × depth at centre (ft.) × $6\frac{1}{4}$ ÷ 4 = total gallonage.

Evaporation must be allowed for also, for this could be as much as five feet through a hot summer. Bores too can sometimes prove most unreliable when heavily drawn upon over a period of time, and it is important to be sure that the water-bearing layer is extensive before installing expensive equipment. It is advisable to test the supply by pumping, at the rate of flow required, for at least 48 hours.

4. **Is sufficient usable land available adjacent to the supply of water?** If the water must be piped for any distance the project could become uneconomical. If much levelling is necessary, this too can be extremely expensive, and it must be remembered that areas which are severely graded off are rarely very productive. Investigate clearing, levelling, channelling and bay construction costs thoroughly.

VALUE AND PRODUCTION

After studying the foregoing points you will realise that the first acre will be an expensive one, but as the size of the project increases, costs per acre will diminish.

What will an acre of lucerne be worth to you? The number of cuts per year varies (with the growing period) throughout the State, so that some districts will produce more per acre than others. However a safe figure, if soil conditions are satisfactory, is approximately 8 tons of baled hay per acre per year. Ordinary wheaten hay is retailed from Carnarvon at £25 per ton. This cost is increased with transport to the property. The price also increases with the distance north. Lucerne hay, weight for weight, contains

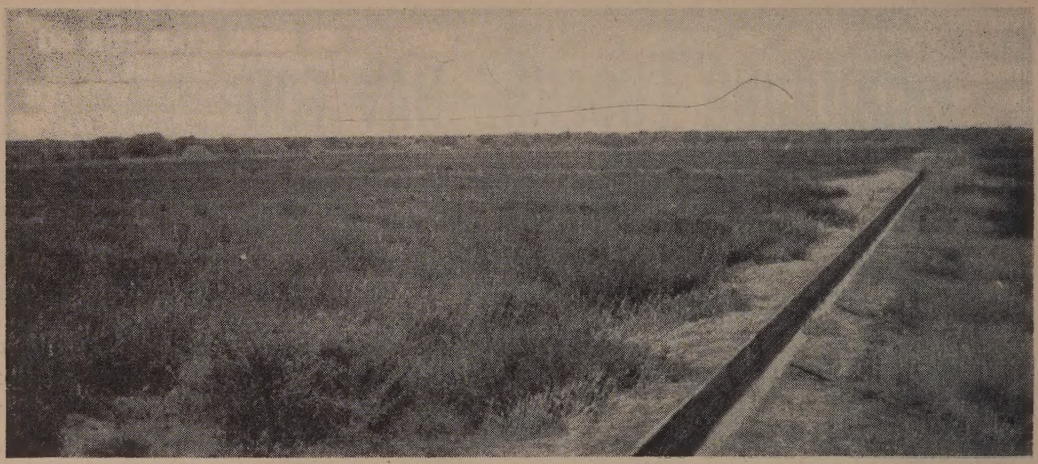

Fig. 1.—A good type of cement channel used for irrigating five acres of lucerne

three or four times the feed value of this, but even when considered at the same price, this would make each station-grown acre worth £200 per annum.

Strangely enough, despite its far greater worth, excellent lucerne hay grown on the Gascoyne is being retailed in Carnarvon at only £27 10s. per ton (and selling slowly), an indication that most local pastoralists are not yet aware of its superior qualities.

PLANTING

The ideal time for planting lucerne varies throughout the north. In the Kimberleys and far North-West, "spring" plantings are rarely successful due to the intense heat which prevails from September until the end of the "wet." During this period lucerne growth is extremely slow as a general rule. The best planting time in those districts is April-May, when the crop has ideal conditions for establishment and weed competition is reduced. In the lower North-West districts satisfactory plantings can also be made in April-May, but at this time of the year considerable weed trouble is often experienced. July, August, September seem to be excellent months for lucerne planting in these more southern districts. Even later plantings are sometimes made but difficulty is usually experienced in establishing a good stand due to the hot easterly winds in early summer.

Where the water supply is nearing the upper limits of salt content (as with some artesian bores) the lucerne is best germinated on the winter rains, since saline water causes a big percentage of seedling mortality. This is best illustrated at "Boodalia," an outstation of "Brickhouse" near Carnarvon. A flowing bore of salt content 140 to 170 grains per gallon is used for irrigation and the lucerne seed was sown in May of 1957. Winter rains were sufficient to germinate the seed and establish the seedlings before any irrigation was necessary. An excellent stand was obtained in this manner, whereas previous attempts to sow and irrigate immediately had been unsuccessful.

The lighter, more friable soil types definitely give better results than heavy clays. On the latter poor germination usually results since the surface crust rapidly sets hard after each irrigation. Seedlings will then often remain spindly for several months, while on the lighter soils quite lush growth can be achieved in the same period of time. It is generally noticeable, however, that once a good stand is developed on clays the growth usually improves, cut by cut, as the roots grow deeper and the surface structure is improved. On the Gascoyne Research Station this has been quite evident in pasture crops. Lucerne which at first would grow no higher than 6 in. before flowering (during the first six months of

Fig. 2.—Lucerne being cut for hay by a power mower

growth) now reaches 15 in. or more after 12 months under regular rotational grazing.

When preparing an area for planting, the soil should be broken up to as great a depth as possible by ploughing. The surface should then be brought to a fine tilth—disc harrows seem to be effective for this purpose. The depth of soil at the chosen site should be greater than 2 ft. for best results. The laying out of the bays should be carried out with great care. One must anticipate that they will last for some years, so the more imperfect they are at the outset, the more trouble will be experienced with them as they age. Very careful attention must be paid to levels at all times.

For flood irrigation, bay construction is not extremely difficult; banks can be thrown up with a mouldboard plough and the resulting furrows can then be filled in with a grader or terracer. These banks should not be too large, since haymaking implements may later have to travel over them. It is good policy, in fact, to aim at wide but very flattened banks (or "border checks") so that they may support a large number of plants which can be cut almost as easily as those inside the bay. This

Fig. 3.—Lucerne hay in windrows after side-delivery raking

gives a complete stand over the whole irrigated area.

Bay length should be given careful thought. If the bay is too long, watering will become a problem as the lucerne stools expand. This is particularly the case if the supply of water being pumped is not large. Five chains should be the absolute maximum bay length. Remember that the shorter the bay is constructed, the more efficient the water usage becomes.

As mentioned earlier, when the lucerne stools expand, water flow in the bays will be retarded. For this reason a slight "fall" is necessary in each bay, the optimum being one inch per chain. This "fall" should be even inside each bay—a series of high or low spots will later cause constant trouble. The bays should also be level from one side to the other.

If earth channels are being used for reticulation, it is advisable to instal cement or piping outlets since the soil washed through from earth stops builds up in the top end of the bay, thus creating too much "fall" and reducing the water penetration. Poor growth will result on such built up areas. Cement outlets for systems which discharge a large volume of water should be reinforced with 2 per cent. by volume of steel rod to prevent cracking.

Sprinkler irrigation is practised considerably in the South-West, particularly where the soil is very light. However this method cannot be advocated for northern conditions since, not only is the initial cost vastly increased but it has been proved on the Gascoyne, that far better growth is produced under the flood system. At the Gascoyne Research Station it has been found, with all sprinkled crops (including bananas), that the "raindrop splash" effect accumulates the clay fraction at surface. The resulting thin hard crust rapidly reaches field capacity, reduces penetration to the lower soil layers, and therefore either causes run-off (if the area is not completely level) or increased evaporation, which in turn increases salt concentration at the surface. Pumping also becomes more costly, and in very hot weather watering must be done at night, which is, of course, a disadvantage.

The sowing rate now advocated for North-West conditions is 20 lb. per acre. Broadcasting of the seed is quite rapid and effective (mixing with coarse sand often makes this operation easier) after which light harrows, i.e., diamond harrows, may be dragged over to cover it.

A light manuring is recommended before sowing. This should consist of 2 cwt. of superphosphate per acre, ½ cwt. of potash (as sulphate or muriate) and 1 cwt. sulphate of ammonia. When regular cuttings are being carried out an annual top dressing of ½ cwt. of potash and ½ cwt. of super will be necessary.

Before the seed is sown it should be inoculated with a bacterial culture, which is now obtainable in a black powder or "peat culture" from stock firms and seed merchants. When purchasing this, be sure to specify the fact that it is to be used for lucerne, and give the approximate weight of seed to be treated. If the bacteria perform their function properly, "nodules" will form on the lucerne roots. When carefully cut open and examined these should contain a pinkish bacterial slime, an indication that the colony is active. This symbiotic association between the bacteria and the lucerne will do away with the need for further applications of nitrogenous fertiliser.

IRRIGATION

Some investigations on watering frequencies are being carried out on the Gascoyne Research Station, where weekly applications are being compared with twice-weekly and ten-day applications. Throughout the winter no particular advantages are apparent as a result of irrigating any more frequently than once every ten days, but as the weather warms the figures are proving that once-weekly watering is essential to maintain the best growth. No advantage is yet apparent from the twice-weekly irrigations. The following figures represent tons per acre of dried lucerne hay:—

	Twice Weekly	Weekly	10-days
July	·95	·63	·88
September	1·57	1·82	1·81
October	2·18	2·3	1·87
November	2	1·98	1·4
December	1·75	1·85	1·64

Fig. 4.—A typical "witch's broom" plant (right) compared with a normal stool (left)

Farther north, in the extreme heat of the pre-wet season months it may be necessary to increase to bi-weekly irrigations to gain maximum yields.

For normal irrigations, if the bays are provided with the correct "fall," the flow into each bay may be cut off when the water is still some short distance from the bottom end. This will prevent surplus water from damaging banks or waterlogging the soil. The distance will naturally vary with the length of the bay. It is quite unnecessary to put inches in depth of water onto the crop—one inch will suffice. Theoretically this would require 22,000 gallons of water per acre, but for practical purposes 30,000 would be a closer figure. Thus, if the bays were covered to a two-inch depth 60,000 gallons per acre would be used.

HAYMAKING

Generally, the first lucerne cut is not raked and baled, but is allowed to lie and form a mulch for the young plants. The main value of this first cut is the effect it has on the plant itself, which stools out, produces more tillers and gains vigour. This first cut is carried out when the crop is six to eight inches in height.

Some people find difficulty in deciding at what stage to cut their crop for hay. The rule in warm months is to await the appearance of the first flowers. In cold months (i.e., June, July and August in the lower North-West) the best policy is to watch for new shoots forming at the bases of the stools, since flowering time is usually retarded for weeks by the cold. In Carnarvon, during winter, the time lag between one cut and the next can sometimes be greater than two months.

When a lucerne area is being cut for hay in any of our northern districts, weather conditions must be given careful attention. When temperatures are over 90 degrees the leaves of cut plants dry out very rapidly and are sometimes shed in half a day, thus greatly reducing the value of the hay. The following are some general rules for lucerne hay making:—

(1) Choose a fine, clear day, preferably not too hot.

(2) Commence cutting early, as soon as the dew, if any, has evaporated from the plants.

(3) Cut the crop as close to the ground as possible. Regrowth from stalks is never as good as that from the crown.

(4) As soon as the leaves have wilted after cutting, rake into windrows. This wilting will usually take less than two hours in northern districts—in fact when temperatures are high it is sometimes necessary to commence raking less than an hour after cutting.

(5) Curing takes little time under warm conditions. A simple test

may be performed by taking a handful of stalks and twisting them tightly. If no sap is evident, baling may be commenced. Needless to say, it is unwise to allow the mower and rake to get too far ahead of the baler. If one tractor is being used for the whole operation, and a stationary baler is the only type of baling machinery available, it is best not to cut more than three acres at a time before baling.

(6) Do not leave the bales in the paddock too long—shift them to a shed for stacking. When baling is being done for the first time some of the bales are often too moist, due to errors in judgment, particularly if those employed in the operation have had no haymaking experience. Any "moistness" will be noticed by those tying the wires or strings, and such bales should be stacked separately, then used as soon as possible since they will rapidly go mouldy.

(7) When the haymaking is completed and the bales carted away it is advisable to introduce a large number of sheep for a day or two so that any uncut stools on the headlands or banks are completely eaten down. This reduces pest and disease carry-over.

(8) Irrigate immediately after the short grazing.

PESTS, DISEASES AND WEEDS

Grubs and leafhoppers are the most serious pests encountered in North-West lucerne stands, but are not extremely difficult to control. Spraying with DDT solution, preferably with a boom spray, is very effective if carried out when the shoots are short (up to 6 in.). As already mentioned, the carry-over of such pests can be partly avoided when remaining stools are grazed down after each cutting.

Two main diseases will be noticed in most lucerne areas in the north—they are "little leaf" and rust. The former, commonly known as "bunchy top" and "witch's broom," can do severe damage to the crop if allowed to spread through it. Indeed, in parts of Queensland areas have had to be abandoned two years after planting, due to this disease. "Little leaf" is caused by a virus, which is transmitted from plant to plant on the mouth parts of sucking insects. Unfortunately many native plants in the north are hosts for this virus, so that affected stools may appear in areas which may seem remote from other diseased lucerne stands. It is obvious that if the spread is to be prevented, spraying must be carried out whenever the number of leafhoppers, etc., is seen to be increasing. It is important to spray jassids (leafhoppers) before they reach the flying stage.

Plants suffering from this virus disease put out excessive numbers of tillers which are spindly and very slow growing. The leaflets themselves are less than one quarter the size of those on a normal plant. It is noticeable in cold or very hot weather that many plants so affected fail to recover from a cut. On the other hand, when growth conditions are ideal it is observed that several healthy shoots often emerge from diseased plants. One Carnarvon grower claims that his crop recovered after a heavy application of potash and super. If the disease is obviously causing a drastic fall in production, the whole patch can be destroyed by spraying with 2-4D when new growth is appearing after a cut. The area is then cultivated again and replanted.

Rust is usually most obvious in the cold months when the plants are making slow growth. Damage resulting from it is only slight and it disappears when regular spring cuts are made.

Weeds generally appear in abundance soon after the crop is first planted; however the young lucerne plants usually outgrow these in height if conditions are all favourable. After the first cut, most of these weeds are relatively slow to produce regrowth, whereas the lucerne rapidly tillers out and outgrows most competitors. Further regular cuts favour the crop to the detriment of the weeds.

However some species can compete strongly with lucerne, and if not controlled can even destroy the stand. In the lower North-West districts, couch grass is the worst enemy, and the only effective

control is complete removal of each small patch before it can become established. This often has to be done by hand. "Crab grass," sometimes called summer couch (*Digitaria sanguinalis*), can also become a major pest if allowed to spread, since its habit is very similar to that of couch. In the Kimberley region, weeds become prolific in the wet season. Here, most of the native grasses can outgrow lucerne in the summer months and regular cuts to control them are often not possible since machinery cannot always be transported to the area. However after the "wet," when cutting is resumed and conditions are more favourable to the crop, the lucerne will usually reappear in abundance. Burr grass, or Gallon's Curse (*Cenchrus echinatus*), is another serious weed on lighter soils in the North-West and Kimberleys. The seed of this, if abundant, can often spoil lucerne hay, in addition to the damage done to the plant through competition. Once again the only really effective control is hand weeding when the first few plants appear. It should never be allowed to seed.

USING LUCERNE HAY

Throughout the north lucerne hay can be used in four ways:—

1. **As a drought supplement for stock.** Little work on the use of lucerne hay as a supplement has been done in this State; however at the Gascoyne Research Station a trial was conducted to investigate the possibilities of feeding it to store wethers for future sale to the butchering trade. Through part of this trial drought feeding conditions were simulated.

Twelve wethers were "free fed" on baled lucerne hay in a small paddock containing wattle scrub. As shown in the graph, their weights increased until the scrub was eaten out completely, when they began to fall away. Not only did the sheeps' body weights decline, but their appetites for the lucerne hay decreased. Whereas 3.2 lb. of lucerne per head was being eaten daily when the scrub was available, this fell to 2.6 lb. per head under true drought conditions. Later, the flock was moved onto an abandoned banana patch where, while green material was available, the weights increased without any supplement. When only coarse and dry roughage remained, a lucerne ration of ½ lb. per head per day, was fed and once again, body weights increased steadily. (See graph).

In a trial carried out in New South Wales, sheep were fed lucerne hay only over a period of time. They consumed a relatively low quantity per day—2½ lb. per head. Instead of being able to utilise the protein from the lucerne, the sheep were actually in negative nitrogen balance—that is, more nitrogen was being excreted than was being eaten (as protein) in the

GRAPH SHOWING TREND IN SHEEP WEIGHTS IN FEEDING TRIALS, GASCOYNE RESEARCH STATION

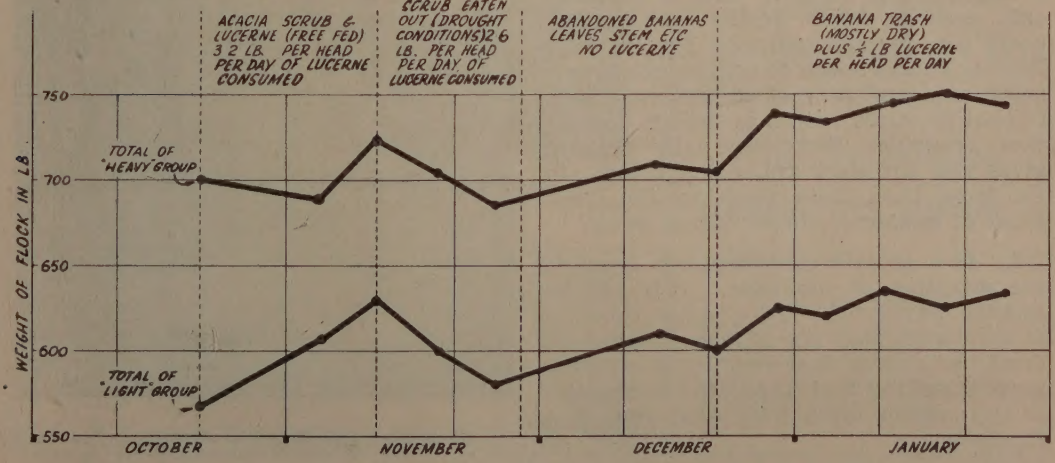
ACACIA SCRUB & LUCERNE (FREE FED) 3.2 LB. PER HEAD PER DAY OF LUCERNE CONSUMED
SCRUB EATEN OUT (DROUGHT CONDITIONS) 2.6 LB. PER HEAD PER DAY OF LUCERNE CONSUMED
ABANDONED BANANAS LEAVES STEM ETC NO LUCERNE
BANANA TRASH (MOSTLY DRY) PLUS ½ LB LUCERNE PER HEAD PER DAY
TOTAL OF "HEAVY" GROUP
TOTAL OF "LIGHT" GROUP
WEIGHT OF FLOCK IN LB
750
700
650
600
550
OCTOBER
NOVEMBER
DECEMBER
JANUARY

Fig. 5.—A three-year-old stand of lucerne badly affected by "little leaf," or "witch's broom"

lucerne. Apparently the all-important ruminal bacteria became geared to dealing with the high nitrogen diet and rapidly deaminated the lucerne protein, forming ammonia, which was absorbed by the blood then excreted via the kidneys as urine. The animals then had to draw on their body nitrogen reserves for their metabolic processes, the waste nitrogen products of which were also excreted.

Bulk of some kind, even if of poor quality, would therefore be necessary in addition to any such high protein product as lucerne hay, otherwise most of the nitrogen will be wasted. Where such bulk is available, about 10 oz. of lucerne hay per sheep per day should be sufficient for a maintenance ration. This is best fed only once or twice weekly rather than every day, for two reasons. Firstly, daily feeding causes sheep to congregate in one small area and not eat enough roughage, so that they lose weight as though no bulk was available. Secondly, daily feeding gives the strongest animals a chance to eat more than their share, to the detriment of weaker or slower eating sheep.

2. **As a protein supplement to improve the digestion of roughage.** This can be applied particularly to spinifex country. It is possible that the protein supplement from the lucerne hay could make spinifex more digestable and stimulate the appetite of the grazing animal for such abundant roughage.

Work carried out in South Africa at the Dohne Research Station has proved the value of a lucerne hay supplement in assisting sheep to utilise completely dry grass pasture. Here the nutritive value of the native pasture is at its best in spring or early summer, but it falls to a minimum in winter months. When given one pound of lucerne hay per head per day as a supplement (fed twice weekly) the test animals actually made small weight gains over the period, whereas those on the dry veldt only, lost over 20lb. per head.

Fig. 6.—Crabb grass *(Digitaria sanguinalis)* has overrun this lucerne stand

3. **As a protein supplement to increase lambing percentages,** is another possible use which is being investigated at Abydos with four objects in view. Firstly, it may be possible that a protein supplement such as lucerne hay could bring ewes into season for planned matings which would give a lamb drop when the pastures are at their best. This may also increase conception rate.. Secondly, a further protein supplement fed to the ewes in the last few weeks of pregnancy, could save many lambs which would normally be lost due to the low plane of nutrition. Thirdly, many more lambs could probably be saved if a lucerne supplement was fed for some time after lambing, thus maintaining the milk flow in the ewe. Rams, also, could perhaps be "flushed" with a protein supplement just prior to mating.

4. **As a protein supplement for working horses.** To date this has been the most common usage of lucerne hay on North-West stations, and in this respect it has proved extremely valuable in helping working horses to utilise the dry grass which is usually the only feed available at mustering time.

On the whole it can be seen that there is scope for considerable research on supplementary feeding in the North, but the indications are that lucerne hay would be a great asset to any station.

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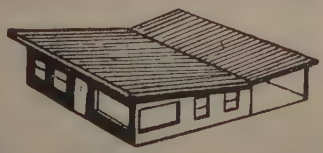

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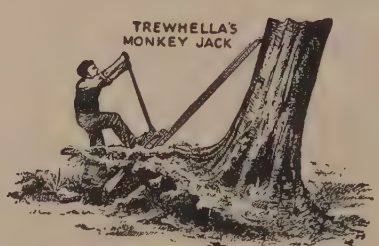

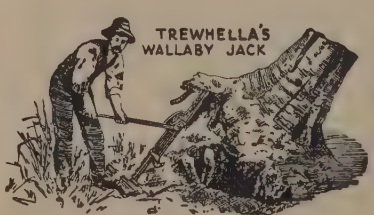

Fig. 1 —A fence following either side of this stony ridge causes no inconvenience to cultivation or soil conservation practices

FARM PLANNING

2.—Fences for Efficient Grazing

By B. a'B. MARSH, Agricultural Adviser, Soil Conservation Service

FENCES can last a lifetime; if they are badly placed they can be a source of frustration for a lifetime. Until they are replaced, they directly and indirectly cause soil erosion and they also obstruct the measures necessary to cure that erosion.

Fences are used to control and confine animals. Fences, therefore, should be placed so that good grazing management is possible. Because grazing management is an essential part of soil conservation, it requires that the type of country, availability of water, movement of stock from place to place and area, all be considered when locating fences. While fences control animals they also tend to impede cultivation and other practices. Fences should therefore be placed so that cultivation is not made inconvenient or likely to cause erosion. Most fences can be kept out of the way of cultivation and contour practices by placing them along natural cultivation boundaries such as creeks, water-courses, rocky ridges (see Fig. 1) and boundaries between land types requiring different cultivation treatment.

Grazing control can be helped by fence planning in several ways. On most farms good grazing control is hampered by poorly placed fences (fences which have been placed early in development and now have no logical reason for being where they are). Watered paddocks are often overgrazed while stock from nearby dry paddocks travel to water. Salty areas are overgrazed to complete bareness simply because they are included in paddocks of normal soil which can be grazed more continuously than salt land (see Fig. 2.)

Several points to consider when planning fences for stock management are described below.

1. **Saline land** can often be more productive for grazing if the salt area is excluded from other land by the use of fences. This allows salt-tolerant pasture plants (and there are many) to become established and the grazing of them to be controlled in such a way that the pasture maintains or increases productivity.

Large areas of such land, unfortunately, seldom have stock water available and as it is best grazed in summer, provision should be made to reticulate water from outside the area.

2. **Poor sandy country,** where it occurs in large enough areas to warrant special treatment, should be fenced so that it can receive the very careful grazing it needs. It is usual for good quality water supplies to be found in these sandy areas, with the result that they are heavily grazed in summer when the vegetative cover on the ground is brittle and the sand dry and liable to blow. Water should be reticulated out of these sandy areas during summer.

3. **Non-arable country,** too steep or stony for cropping, usually occurs in small areas. If these areas extend over a long distance and form a barrier to cultivation, they can be considered as possible fence lines, fence lines which will be completely out of the way of cultivation and contour practices. If these non-arable areas are large enough to be grazed as separate units, then they should be fenced and watered and grazed separately. If large areas are not fenced from land which is cropped, then during the year of cropping the non-arable area is lost from grazing.

4. **Water supplies** must be available to stock in every paddock. If paddocks do not have water, gates have to be left open and the trampling by stock causes erosion damage. Efficient grazing is only possible with water supplied in every paddock.

When fences are placed along natural boundaries as suggested in this series of articles, it is often found that water supplies occur near these fences, for example in drainage lines and near the boundary of sandplain country. Fences should be taken near water supplies so that reticulation is not made costly. Subdivision should be arranged so that no paddock is short of water.

When carrying out subdivision planning, it must be remembered that fences are to control and confine animals; there is no need to separate soils requiring different erosion control treatments.

Fences are for efficient grazing. Fence then according to the factors which make grazing efficient. While doing so, try to keep the fences out of the way of other farm practices. Remember, if there were no animals, there would be no need for fences.

Fig. 2.—The salt in the foreground grows nothing; it could be made reasonably productive. The fence serves no logical purpose, and it has since been replaced along the salt boundary where it can be used to allow correct grazing, safe cultivation and safe firebreaks

Severely salt-affected country underlain by a shallow saline water-table

GYPSUM FOR SALT LAND?

By T. C. STONEMAN, B.Sc. (Agric.), Agricultural Adviser, Soils Division

GYPSUM is used in many parts of the world as a soil dressing for the reclamation of "salty" country. Farmers have asked whether such applications would improve salt-affected soils in Western Australia. The answer to such questions is that tests made over a period of 20 years, using gypsum on salt-affected soils in various parts of the wheatbelt, have failed to reveal any benefits accruing from even very heavy applications.

In order to understand why a soil treatment, which gives good results in other countries, is a failure in Western Australia, it is necessary to consider firstly, the characteristics of various types of salt-affected soils, and secondly, the manner in which gypsum reacts with the soil constituents to provide a beneficial effect.

CHARACTERISTICS OF SALT-AFFECTED SOILS

There are two quite distinct, but nevertheless sometimes overlapping, types of problem soils under this main heading.

Firstly, there are those soils in which soluble salts have accumulated in the root zone to such an extent that plant growth is adversely affected. This is the type of problem which occurs most commonly in Western Australia. In these soils, the salts remain as such in the soil solution, the only effect being to produce a concentrated salt solution from which the plant roots have to extract moisture and nutrients. The result is that as the concentration of this solution increases, it becomes more and more difficult for the plant to extract its requirements of water from the soil. The final stage is that plants, when in a sufficiently salty soil, eventually die of drought even though the soil may appear quite moist. One important characteristic of this type of soil is that the presence of these salts does not influence, to any great extent, the structural properties of the soil.

The second type of salt-affected soil is one in which the sodium part of the salt

(sodium chloride) becomes attached to the clay particles of the soil. The presence of a large quantity of sodium on the soil clay has the effect of producing a poor soil structure and, in particular, a very much reduced permeability to water.

HOW GYPSUM AFFECTS SOIL AND SALT

A clay with much sodium attached to it has a poor structure. On the other hand, a clay with predominantly calcium attached to it has a good physical condition. The object of applying gypsum which is a calcium salt (calcium sulphate) is to replace the sodium on the clay with the more desirable calcium. The sodium thus displaced can then be washed or leached from the soil leaving a soil with good physical characteristics.

It is clear, then, that gypsum is only used on salt-affected soils to correct the sodium effects, and indirectly where salt and sodium effects exist together, to enable a leaching out of the excess amount of salts by producing a more permeable soil. Also as gypsum is not freely soluble in water, it is necessary to have large amounts of water, either as rainfall or as irrigation water. Again, in order for the replacement to continue, the "by-products" of this replacement must be continually removed by downward-moving water.

In all these cases, large quantities of relatively fresh water are required. Nowhere in the wheatbelt of W.A., where salinity is a problem, can these conditions be met. As mentioned earlier, the main salinity problem in W.A. is in the first category where only the presence of soluble salts in the soil is the problem, and for this class there is no reason to expect the application of gypsum to be of use.

It is also possible to get the two sets of conditions occurring together, in which there are excessive amounts of soluble sodium absorbed on the clay particles. These conditions do exist but only to a very small extent in this State, in association with the main type of salinity problem indicated above.

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OATS AND VETCHES *Demonstrations*

By F. E. RYAN, B.Sc. (Agric.), Agrostologist

CROPPING of oats is a common practice in the higher rainfall areas of the South-West and is frequently used during the process of ploughing up run-out pastures prior to reseeding. Combinations of vetches with the oats for this purpose have received more attention in recent years and this practice has been widely demonstrated during the last five or six years with excellent results.

The advantages of a crop between ploughing up and reseeding to pasture are:—

(1) An opportunity is given for weed control during the autumn and perhaps early winter before sowing the crop.

(2) The crop itself has a smothering effect on weeds which germinate afterwards, resulting finally in a clean paddock ready for resowing to pasture next autumn.

(3) It provides a bulk of fodder for conservation.

(4) The cultivation and smothering effect of the crop permits early autumn sowing of pasture in the following season.

(5) This technique is successful in the introduction of improved pasture species.

The advantages of a vetch-oat mixture over oats alone are:—

(1) A much better quality hay, rich in protein is produced.

(2) In some cases, the total yield of the vetch-oat crop may be greater than might be expected from oats only.

In sowing a mixture of vetches and oats the only variety of oats which has been recommended is Algerian as this variety parallels reasonably well the growth of the vetches, both making strong growth in the late spring.

Seeding rates are 60lb. of oats to 15lb. of vetches per acre. In the heavy rainfall districts, best results have been obtained from the commercial Purple Vetch and this variety can be recommended in all districts.

The possibilities of using this crop were demonstrated on seven properties during the winter period of 1956 with the following results.

Thomson's Brook.

The soil on the paddock chosen was a gravelly loam previously carring redgum and jarrah. It had been sown to pasture when first cleared 21 years previously but had deteriorated very seriously and was carrying only capeweed, flatweed and poor native grasses.

The paddock was ploughed and cultivated during autumn, 1956 and drilled in on 12/7/56 using 60lb. Algerian oats and 15lb. Purple Vetch per acre. It was fertilized with molybdenum superphosphate at the rate of 2 cwts. per acre. During late winter the paddock became wet and vetches were backward. Eventually however, plants recovered well and spring growth was very good. The estimated yield was 38 to 40 cwts. per acre and consisted of a good mixture of vetches and oats.

The area on which the crop was sown in 1956 was sown down in the autumn of 1957 with midseason sub. clover and H.1 ryegrass. This demonstration was considered very successful in showing the value of this vetch and oat mixture as a hay crop in the Thomson's Brook area and also the value of such a crop for the control of weeds and in the preparation of an early weed free seed bed ready for sowing down to pasture species in the autumn following the crop. The paddock was inspected by members of the Donnybrook Pasture Improvement Group during farm walks held during the year and in spite of a late planting, grew a successful crop.

Charlie's Creek.

This demonstration was laid down on a deep loamy soil with some gravel. The area originally carried jarrah and redgum and had been cleared for 30 years. It was previously sown with pasture nine years before but had seriously declined and consisted mainly of capeweed and annual grass species. It was situated on a hillside with good drainage.

Following late ploughing, this area was disc cultivated, harrowed and broadcast on July 15. Germination was good and the crop made excellent progress during the spring months. Some irregularity in the proportion of vetches to oats occurred and this is considered due to an uneven distribution of seed when broadcasting. The crop provided an excellent yield of good quality hay.

In an adjoining paddock the farmer had sown vetches with an early variety of oats. These oats grew rapidly in the early part of the season and, as a result, tended to choke out vetches which were sown that year. A mixture of vetches with an early variety of oats was not nearly as successful as the combination of vetches with Algerian oats.

A field day in the Donnybrook area included this property.

Crooked Brook.

The site chosen was on a deep medium loamy soil with excellent drainage. The area previously carried jarrah and redgum and had been cleared for about 20 years. It was last sown with pasture eight years before but had seriously deteriorated and before cultivation, consisted of capeweed, flatweed, geranium and poor native grasses.

It was ploughed during the late autumn and cultivated with a rigid tyne scarifier. It was sown on June 28 by broadcasting and the seed covered by harrowing. A good germination of both oats and vetches was obtained and growth during the early spring was satisfactory, both oats and vetches making strong growth at this time of the year.

The area was cut for hay at the end of the year and provided an excellent hay crop of high quality. On this paddock it was also very successful in cleaning weeds prior to resowing to pasture. H.1 ryegrass and midseason sub. clover were to be sown on this paddock during 1957.

Weed control throughout was very successful and only a small amount of capeweed occurred on the sown area. The demonstration was considered very successful. This farmer will plant 10 to 12 acres of oats and vetches next year as part of his farm programme.

Cowaramup.

This demonstration was laid down on a gravelly loam soil and was sown during early May. Germination was excellent of both species. Owing to the vigorous growth of oats on this area a grazing was carried out during mid-August to control the excess growth of the oats. At that time both species were growing well but the oats were tending to overshadow the vetches. Following grazing the area was closed up to be left for hay.

By the end of November, the oats had reached a height of 4 to 5 ft. with the vetches almost as high. The two acres of this demonstration gave a yield of 210 bales of hay with an estimated yield of between 46 and 50 cwts. per acre. In the better parts of the crop it was estimated that vetches contributed between 60 and 70 per cent. of the hay crop. The crop was also very successful in controlling weeds, since the smothering effect of such a heavy crop prevented weeds from developing seeds.

The Cowaramup Pasture Improvement Group conducted a farm walk on the site and a number of interested farmers inspected it during the growing season.

Forest Grove.

A grey-brown sandy loam soil on a hillside was chosen for this demonstration. It had been cleared for many years and sown down to pasture.

The area was disc ploughed except for one section which was only tandem disced. This area was too wet to plough. The demonstration was sown in mid-May and a very good germination of both oats and vetches was obtained. Growth was somewhat slow during the winter months but in early spring was satisfactory with the oats tending to dominate the vetches. At this late stage however, no grazing was carried out particularly as the area was somewhat wet. Some difficulty was experienced in the nodulation of the vetches under the wet situation but a reasonable number of plants survived.

The demonstration was used during the farm walk held by the Forest Grove Pasture Improvement Group.

Bridgetown.

Soil chosen for this demonstration was a red, loamy soil with some gravel. Drainage was good. The land had been under pasture for many years and had reverted to Guildford grass and weeds. The surface was scarified in the early autumn and the first germination of weeds was tandem disced and left fallow for four weeks, then disced again. Further discing and harrowing took place during May and the demonstration was sown down on June 13 by broadcasting.

A very good germination was obtained and growth during the year was exceptionally good. Vetches made strong growth but the oats were a little slow. By the end of August a very good stand of both oats and vetches had been obtained. Late spring growth was very strong and the paddock was harvested for hay on December 12, 1956, yielding approximately 90 cwts. of hay per acre.

The control of Guildford grass and other weeds was very successful and the farmer is very pleased with the results obtained from this crop.

The paddock was visible from the main road and raised a number of comments from farmers passing the area. It was sown down to perennial pasture species during 1957. This crop was considered very successful.

Denmark.

This demonstration was sown down on a reddish-brown loamy soil. Sowing was late on a rather roughly prepared seed bed. In spite of this a reasonably good germination of oats and vetches was obtained. This crop was cut for hay during the late spring. No estimate of yields is available.

Waroona.

Oats and vetches were sown on this area during May, but later the paddock became somewhat waterlogged and the nodulation of the vetches was seriously impaired. During August the area was grazed with stock and the vetches failed to recover.

This demonstration was not successful. The main cause of failure is considered to be the wet nature of the paddock and the consequent failure of the vetches to nodulate. Very close grazing during August prevented any recovery by either oats or vetches.

SUMMARY

A total of seven demonstrations of oats and vetches were arranged throughout the dairying districts during the autumn-winter, 1956. In each of these, 60lb. of Algerian oats and 15lb. of vetches were sown per acre.

One demonstration was considered a failure owing to wet conditions and a lack of nodulation of vetches, but the remaining six demonstrations were considered to be satisfactory and yields of hay from these areas were estimated at between 38 and 90 cwts. per acre.

In most cases a very good mixture of oats and vetches were obtained but where the paddock was wet during the wintertime, nodulation of the vetches was sometimes less. The inclusion of a legume with the oats provides a hay of much higher protein content which is more valuable for feeding to dairy cattle or for fattening during the summer months.

In all demonstrations weed control was found to be very good and the influence of the heavy crop in smothering late germinating weeds was very noticeable.

The value of Algerian oats in conjunction with vetches was demonstrated on one property where an adjoining crop had been sown with an early-maturing variety of oats. This crop which had been sown with the early-maturing variety contained a lower proportion of vetches to oats when fully grown.

In all cases preparation has been made for the resowing of these paddocks to improved pasture species.

Demonstrations are arranged through the various district officers and in most cases these have been conducted in conjunction with local Pasture Improvement Groups. The demonstrations are arranged so that farmers of a district may have the opportunity of observing the growth of these and similar crops.

If you are interested in the demonstrations which are being carried out in your district the local district officer should be contacted.

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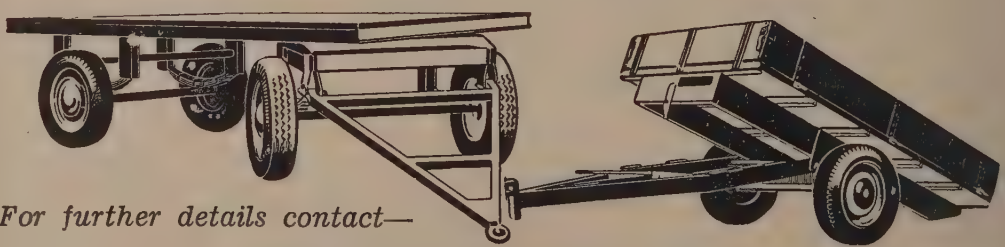

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RAGWORT

(*Senecio Jacobaea* L.)

Ragwort is recorded as being native to Europe, Siberia and North-Western India, but has spread to many other countries, including North America, New Zealand and Australia. Besides competing strongly with pasture species it has been responsible for losses among stock.

WEEDS of Western Australia

By **G.R.W. MEADLY** M. Sc.
Officer in Charge, Weeds and Seeds Branch

RAGWORT

(Senecio Jacobaea L.)

RAGWORT is a biennial or perennial herb native to Europe, Siberia and North-Western India. It is recorded as a weed in parts of its natural habitat, particularly in England, and has also spread to other countries, including North America, New Zealand and Australia. In Canada it is found in all provinces on the Atlantic seaboard and also occurs in the United States. Conditions have proved very favourable in New Zealand where Ragwort thrives on large tracts of country.

It is widespread in parts of Victoria, particularly in Southern Gippsland and is a troublesome weed in Tasmania where dense stands develop. It also occurs on the Southern Tablelands of New South Wales. Ragwort was first recorded in Western Australia in 1940 when a Manjimup farmer, noticing an unusual plant, forwarded a specimen to the Department of Agriculture for identification. An inspection revealed that the weed was restricted to about 100 square yards of pasture on partly-cleared land. The plants were mainly clustered together and could have originated from a single plant.

Following the publicity given to this occurrence an observant settler reported the weed on his property at Pemberton. Both areas were treated with sodium chlorate and no plants have been found at either site in recent years, underlining the importance of early recognition of weeds.

The history of its appearance in both localities indicated that the weed had been introduced as an impurity in agricultural seeds. In recent years a further infestation has been located at Walpole where control measures are being undertaken. This is the only known area of Ragwort in Western Australia.

DESCRIPTION

Ragwort is a biennial or perennial herb, reaching a height of 2-3 ft. from a short thick root-stock which divides with age. The erect stems are usually a bright purple in colour. The leaves are pinnate with ovate or narrow, coarsely-toothed segments, the terminal ones being larger. The basal leaves have long stalks, while the uppermost are sessile. The yellow flowers are abundant, the heads being in compact or broad terminal corymbs. The small seeds have a feathery pappus and a single plant may produce as many as 50,000 seeds each year. Flowering occurs during the summer months.

Wort is an alternative name for weed and "rag" is probably an abbreviation of "ragged," descriptive of the leaf edges. The plant is also called Tansy ragwort and Staggerwort.

SIGNIFICANCE

Ragwort is a weed of pasture land and waste places rather than arable land. The vigorous growth, particularly of basal leaves, makes it a very strong competitor. It is most likely to intrude into unthrifty pastures where bare patches occur and is of less significance when competing with strongly-growing perennial pasture species.

RAGWORT

(*Senecio Jacobaea* L.)

A.—Plant showing stock and basal leaves along with stem leaves and flowers. About one foot of the central portion of the stem has been removed; B—Details of stock and basal leaves; C.—Single basal leaf; D and E.—Flower heads, the latter showing the dark-tipped bracts; F and G.—Single flowers; H.—Achene (seed)

(From a pen drawing by the Government Botanist, C. A. Gardner.)

Another characteristic, however, renders it more serious as a weed. Certain diseases of stock in various parts of the world have been attributed to species of *Senecio*, especially *Senecio Jacobaea*. These troubles include "Pictou disease" of cattle and horses in Canada, "Winton disease" of horses in New Zealand and "Molteno disease" of cattle in South Africa. A common feature of all these is the development of hepatic cirrhosis in the affected animals. Symptoms appear after a considerable quantity of the plant has been ingested, and cases of losses among horses and cattle have been reported from all countries where the weed occurs abundantly. An alkaloid is considered to be responsible.

Formerly, sheep were regarded as being immune, but experiments have disproved this assumption. They are less likely to be affected than horses and cattle, however, and in New Zealand, heavy stocking with sheep has been used as a control measure. This must be done with discretion, however, if ill effects are to be avoided.

Ragwort is a declared primary noxious weed for the entire State.

CONTROL

As already mentioned, Ragwort seeds very freely and the seeds can be carried considerable distances by the wind. Every effort should be made, therefore, to prevent seed formation. If cut at the flowering stage and left, at least a proportion of the seeds will mature. Owing to the strong perennial root development, grubbing must be carried out very thoroughly if it is to prove effective and spasmodic cultivation serves to distribute rather than eradicate the weed.

Pasture improvement is giving good results on some bad infestations in Victoria. Where practicable, the area is ploughed and, following two consecutive years of cropping, is sown with vigorous pasture species. The objectives are to obtain maximum shading and smothering from the crops followed by competition from the pastures.

Chemicals are also effective and their use has been practicable with the restricted areas of Ragwort found in Western Australia. With the early infestations, a 5 per cent. solution of sodium chlorate proved effective but, latterly the growth-regulating herbicides, have been used. From 1½ to 2 lb. acid equivalent of 2, 4-D ester per acre is sufficient for seedlings but higher rates approximating 4 lb. per acre are used for established plants. This treatment would kill or severely affect most clovers. For this reason and also because of the cost, spot spraying rather than boom application is recommended. Low-volume treatment is seldom effective. The best time for spraying appears to be when the flowering shoot is making rapid growth but before the buds have commenced opening.

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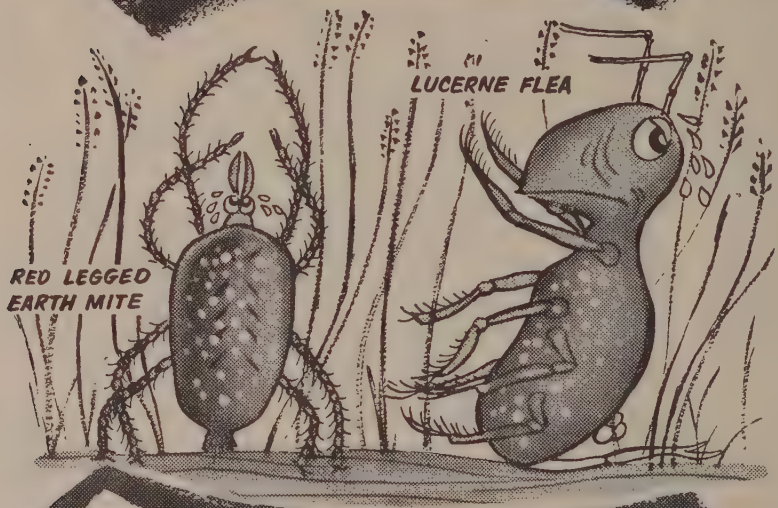

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MAIZE FOR FODDER OR GRAIN

By F. E. RYAN, Agrostologist

(Revised from Leaflet No. 745 by H. G. Elliott.)

MAIZE, being indigenous to the warmer parts of either Southern Mexico, Central America or Northern South America, thrives best under warm, moist conditions. It is susceptible to frosts and must be grown in regions which are free from them during the growing season. The plant is fairly drought-resistant, providing the ground is in good condition and well cultivated between the plants, until the tasselling period. Ample evidence has been obtained in this State to show that maize can be grown successfully for both green feed and grain in the south and west coastal on summer moist land and irrigation areas.

Maize can be grown on a variety of soils, but is best suited to a deep sandy loam containing ample organic matter.

For the production of grain the critical period is the tasselling stage, and warm weather with ample soil moisture at this time is essential for heavy grain crops. These conditions can be assured by irrigation or by growing the crop on "summer moist" land.

PREPARATION OF SEED BED

As maize is deep rooting, the soil should be ploughed to at least six inches, for preference with a mouldboard plough, which will bury all green material and trash which may occur on the surface. This ploughing should be done in the early spring so as to give the soil opportunities to mellow. The final preparation consists in obtaining a surface layer of some two inches of reasonably fine soil in which to plant the crop. It is necessary to compact the seed bed, and this is best done by double discing and harrowing and, if necessary, the use of a roller followed by a further harrowing.

TIME TO PLANT

Maize should be planted late enough to escape frost in the spring and early enough to miss the frosts in the autumn. October to December will be found the most suitable planting months.

VARIETIES

The white-seeded open pollinated variety, Hickory King, is most favoured for green feed in this State but in recent years a number of new hybrid varieties have become available. These varieties have been developed mainly for grain production and are capable of higher grain yields than Hickory King. Best varieties for this purpose in Western Australia are those with earlier maturity such as Dawn, Emblem and DS28.

Most hybrid varieties have not proved more productive of green fodder than Hickory King but some of the later-maturing varieties such as Standfast have been promising in recent trials. Under droughty conditions earlier-maturing hybrids have given good results.

SEED SELECTION

For future crops, farmers should select their own seed, not by picking likely-looking cobs from the crib at the time of shelling, which will give fair results if conscientiously carried out, but by selecting cobs in the field, by paying attention to the type of plants and types and number of cobs produced per plant. Healthy vigorous plants with cobs that have a pronounced drooping tendency is desired. If, when mature, the cob is pointing towards the ground there will be little or no damage from water gaining access to the grain, if rain falls prior to harvesting.

DO NOT SAVE SEED OF HYBRID MAIZE VARIETIES

Hybrid maize seed is specially grown by crossing selected parents. The seed of the first cross has the greatest hybrid vigor. Consequently fresh seed should be purchased for each sowing. Saving seed from stands of hybrid maize varieties is not recommended.

RATE OF SEEDING

Maize for grain is either planted in "drills" or "hills." In this State the former method is recommended. The seed is sown in drills about 3 ft. apart with about 12 in. between seeds if under good moist conditions. With drier conditions the rows should be 4 ft. apart with 16 in. between plants. Eight to 10 lb. of seed would be sufficient to sow an acre.

Heavier seeding rates are used when maize is grown for fodder and rates as high as 40 lb. of seed per acre are sometimes sown broadcast. Trials carried out in recent years suggest that 40 lb. per acre seeding rates may be excessive and good results have been obtained with 20 lb. per acre. Broadcast sowing or close drilling results in finer stems and this is a desirable character for fodder purposes.

DEPTH OF PLANTING

Two or three inches deep is considered the best depth to sow, but the seed can be sown to four or five inches deep if necessary to ensure being placed into moist soil.

FERTILISER

It is normally recommended to use at least 3 cwt. of potato manure per acre, the fertiliser being sown in drills, but not in direct contact with the seed if this can be avoided. The type of fertiliser used will vary with the soil on which maize is sown. An application of at least 1 cwt. per acre of sulphate of ammonia is suggested on very sandy soils and 1 cwt. per acre of muriate of potash on soils suspected of potash deficiency.

METHOD OF PLANTING

Single and double row maize machines for planting can be obtained. These machines are desiged to sow the grain at regular intervals and are fitted with an attachment for applying the fertiliser. The machines open the furrows, drop the seed, cover, and press them into the soil in one operation. When planting under

Portion of the maize trial plots at the Denmark Research Station.

irrigated conditions it is recommended to sow in rows 4 ft. apart and run an irrigation furrow in between each double row.

AFTER-PLANTING CULTIVATION

This is essential for control of weeds and to increase soil aeration. The cultivation should begin soon after seed sowing and continue, if necessary, until the plants reach five to six feet high. Single or two-row cultivators are recommended. The depth of cultivation should not exceed two to three inches or injury to the roots is likely to occur. Two to four cultivations should be sufficient during the growing season.

GENERAL

Some farmers practise the method of following on a potato field with maize and occasionally pumpkins. After the potatoes have been lifted, the ground is thoroughly cultivated and packed and the maize seed sown as explained in the foregoing information. If, however, pumpkin, or a leguminous crop is grown in association, the maize may be spaced at six to eight feet between rows and the other crop inter-rowed. Fertiliser is not usually applied, as it is considered that sufficient is available from the prior potato crop. It is recommended, however, that a small application of potato manure be applied at the time of planting.

HARVESTING

For grain, the most common practice is to allow the crop to stand in the field until the grain is quite ripe, a condition which is shown by the husks becoming dry and hanging down. The cobs are then gathered by hand and husked in the field or in a shed.

The grain in the husks should be quite dry before storing, otherwise it is likely to heat and mould. Until thoroughly dry, the cobs can be stored only in open sheds with free air circulation.

Husking and shelling can be carried out in the winter months and shelling is done best by using a maize shelling machine, which can be operated by hand or power. The grain is then graded, if necessary, and bagged for sale. It is sold by the bushel, which means 56 lb. weight. It has been estimated that about 75 lb. weight of "ears" will produce about one bushel of grain.

The "core" although of low feeding value can be ground and used as a meal.

The stalks and leaves ("stover") left after the "ears" have been removed, contain about one-third of the total food produced by the plant, and can be harvested, and chaffed or shredded for feeding to horses or cattle as a maintenance food during the winter.

The modern practice is to cut the crop after the grain has commenced to colour and dent, and tie the bundles, stook until the grain is dry and the stalks cured, which takes approximately five to six weeks. The cobs are then removed and the fodder stored away until required.

Maize is usually harvested for fodder as soon as grain in the cobs has reached the milky stage. If feeding is desired over a long period, planting can be "staggered" to allow for early and late cutting.

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Fig. 1.—Wallabies in a trapping yard

THE KIMBERLEY WALLABY MENACE

Water Poisoning Experiments 1955-7

By C. D. GOODING, B.Sc. (Agric.), Research Officer, and
J. L. LONG, M.D.A., Research Technician

SINCE 1952, the Agriculture Protection Board has been investigating means of controlling the Kimberley Wallaby or Sandy Wallaby (Macropus agilis). Much work has been done on the use of solid bran and pollard baits containing strychnine, but it has been shown that these can only be used along the well watered alluvial "frontage" country, during periods of comparative drought, when feed is practically nonexistent. It was at this stage that our attention was turned to water poisoning in an effort to bring some annual relief to the pastoralists in the area.

The problem of the Sandy Wallaby in the West Kimberley region resolved itself into two clear-cut phases. The well-watered alluvial country cannot be handled by water poisoning but the drier "pindan" country (in most places) can. In this area, stock (and the wallabies) have to rely on man-made waters, in the form of bores and mills for the greater bulk of their supplies of water. It thus appeared obvious that in this region water poisoning offered the greatest possibilities as a means of control. It was with this knowledge that initial experiments were started in September, 1955.

BASIC INFORMATION

The first step was to gather basic information such as the amount of water consumed by each wallaby and the amount of each of the poisons required to kill. After this knowledge was obtained, poisoning tests could be undertaken and such facts as the time required to poison out a mill could be ascertained.

Fig. 2.—Portion of a large area dug up by wallabies in search of ribbon-grass roots. The complete destruction of plant cover may lead to soil erosion

Water Consumption Tests.

In the initial stages, observation of the wallabies whilst drinking showed that they sometimes drank several times over a period of an hour or more. They would often drink, then hop back a little way from the trough only to return later for a further drink. If they ware disturbed during these periods of browsing near the trough they may hop away altogether. It became apparent that we must measure the quantity of water consumed at their first drink from the trough, if we were to be sure of obtaining a kill. This we termed the "volume consumed at first drink" and was the figure used in all future work on water poisoning. Whilst recording these figures the animals were also weighed and sexed and the data is listed below in Table I.

The smallest amount consumed in any one case was 10 fluid oz., there being only four records of less than 1 pint. The largest amount consumed in one drink was 62.6 fluid oz. (just over 3 pints). (A further weight check showed that 106

Table I.

WATER CONSUMPTION AT FIRST DRINK.

Sex	No.	Average Weight in pounds	Average Amount Consumed
Males	12	24·75 lb.	45·4 fl. oz.
Females	13	15·80 lb.	27·8 fl. oz.
		Overall average	36·2 oz.

males averaged 24 lb. and 100 females averaged 16 lb. giving an overall average of roughly 20 lb.) Thus enough poison to kill a 20 lb. animal must be incorporated in each 36 fluid oz. of water if one is to work on averages. However, as a margin of safety is necessary we decided to work on 1 pint as the volume of water containing a lethal dosage.

Lethal Dosages of the Poisons Arsenic and "1080."

From previous work on baiting it was known that a dose of 0.2 mgms. of "1080" per pound body weight was lethal to these animals. Similar work was then carried out with arsenic pentoxide (a water soluble arsenic salt)—giving a figure of 7.5 mgms. per pound body weight. This meant that for a 20 lb. wallaby we would need 4.0 mgms. of "1080" or 150 mgms. of arsenic pentoxide. Both of these poisons are rather slow in their action. This is a factor that some pastoralists consider disadvantageous since one has no check on the numbers of animals poisoned, or for that matter on the effectiveness of the poison. It was decided in an effort to obviate this factor, to try various increases in concentration until more animals were found dead near the trough, thus illustrating the effectiveness of the poisoning.

Palatibility of the Poisoned Solutions.

This then introduced the next factor of palatibility (or repellency) of the more concentrated solutions. More repellency was expected with arsenic pentoxide than with the comparatively tasteless "1080," so a verification test was run using this poison—see Table II.

In this test five standard containers were sunk into the ground at the usual watering place of the wallabies, until the lips were flush with the surface. The animals had a free choice as to which container they used. The quantity of each solution consumed was measured at regular intervals and their positions rotated.

The figure for the water (control) was then taken as 100 per cent. and the others expressed as percentages of that figure. During this test numerous wallabies were seen to move from trough to trough sampling the water.

Table II.

PERCENTAGE OF As_2O_5 SOLUTIONS CONSUMED.
(Compared with Water.)

	Water	Arsenic Pentoxide per 100 gallons			
		6 oz.	12 oz.	24 oz.	48 oz.
Quantity of each mixture consumed	% 100	% 73·3	% 85·4	% 38·0	% 21·0

Individual Consumption.

A further check was taken on the effectiveness of these concentrations as poisoning agents, using arsenic pentoxide. Wallabies were allowed to drink one at a time at these five containers. After drinking they were shot and weighed. After measuring the volume of solution consumed it was possible to calculate whether death would have ensued. The results are summarised in Table III.

It would therefore appear that 6 oz. per 100 gallons requires too large a volume of solution to make sure of death under these conditions. Solutions of 24 oz. and 48 oz. per 100 gals. seem to have some repellency. (This is borne out in previous table). It was then decided that 12 oz. per 100 gals. was the most suitable of these concentrations for water poisoning Sandy Wallabies under these conditions.

As a check to see if other soluble arsenic salts were as palatable as the pentoxide a simple test was performed in which sodium arsenite and the pentoxide, at similar concentrations, were exposed to the wallabies' free choice. For every 100 parts of arsenic

Table III.

MORTALITY FRACTION WITH VARIOUS CONCENTRATIONS OF ARSENIC PENTOXIDE.

Concentration As_2O_5 per 100 gals.	6 oz.	12 oz.	24 oz.	48 oz.
No. killed/No. drinking	3/5	5/5	5/5	2/2
No. licking only, then moving to other container	....	....	3	3

pentoxide, 86 parts of sodium arsenite was consumed. Besides this, arsenic pentoxide contains 65.2 per cent. arsenic, whilst sodium arsenite contains only 57.6 per cent. **It was thus concluded that 12 oz. of arsenic pentoxide per 100 gallons of water was the best concentration of an arsenical poison that we had investigated for the water poisoning of Kimberley Wallabies.**

Strychnine.

The water at one experimental mill was poisoned with strychnine. Results appeared to be good but it was found difficult to eliminate the bitter taste associated with this poison. It was considered that arsenic pentoxide and "1080" showed greater promise.

"1080."

Previous work in connection with baiting had shown that the lethal dose of "1080" for these wallabies was 0.2 mgms. per lb. or 4.0 mgms. for an average 20 lb. animal. As this poison is reported to be tasteless it was not thought necessary to conduct any palatability tests. Field tests were instituted to gather such information as the time required to poison the greater bulk of all wallabies watering at a mill.

Table IV.

FIELD POISONINGS.

Mill Name	Concentration "1080" Used	Volume Consumed Each Night (%)					
		1st	2nd	3rd	4th	5th	6th
Boab Dam	3 grams/100 gals.	100	100	79·5	67·0	6·0	....
Thompson's Dam	5 grams/100 gals.	100	95·5	79·3	61·4	5·0	....
Curtain's	10 grams/100 gals.	60·9	31·7	2·4	4·8	4·0	....
Forrest's	18 grams/100 gals.	162	150	100	25·0	0	....
Mickie II	20 grams/100 gals.	92·3	3·8†	†	†	83·0	6·1
Mickie I	40 grams/100 gals.	100*	100*	83·3	16·6	0·3	....
Hunter's	40 grams/100 gals.	138·6	68·1	0	2·2	0	....
Egan's	40 grams/100 gals.	200·0	300·0	500·0	2,200·0	1,200·0	....

ARSENIC PENTOXIDE.

Mill Name	Concentration Used	Volume Consumed Each Night (%)					
		1st	2nd	3rd	4th	5th	6th
Lelvier's	12 oz./100 gals.	160	88·0	11·2	2·0	1·5	....

* Cattle watered, cleaned out trough.

† Mill Tank overflowed, fresh water available, poisoning recommenced on 5th night.

Fig. 3.—Typical Fitzroy River frontage country showing lack of herbage

Table IV shows the results of experimental poisoning of mills using various concentrations of "1080" (and one arsenic pentoxide record).

A record of the amount of water consumed each night was kept for two or three days before poisoning commenced. The results are expressed as percentages of this "free water" consumed.

Forrest's Mill.—Note here the effect of poisoning in strange troughing. The consumption of poison on first and second nights was greater than the consumption of unpoisoned water. This is more clearly illustrated at—

Egan's Mill where the consumption, although small in quantity, continued to increase until the fourth day of poisoning, before any decrease was noticeable.

If we exclude the unusual factors such as cattle watering, strange troughing or mill breakdowns, it is seen that three to five nights' poisoning was all that was necessary to reduce the numbers of these pests watering at each of the mills and dams tested to a very low level.

There are several facts which are important in the application of these results, which have not yet been discussed. These include:—

(a) The exclusion of stock.

(b) The effects on native fauna.

(c) The length of poisoning season.

EXCLUSION OF STOCK

Up to the moment there is nothing new to report in this field. The methods of stock exclusion that can be used are merely fencing and the provision of new troughs. The removal of poisoned water each morning will also be necessary if the existing trough is being used, and stock are in the paddock.

Where one mill waters more than one trough it should only be necessary to poison one trough at each mill. The other troughs, however, will have to be drained each night and filled with fresh water again next morning. If four paddocks are served by each mill the mustering of stock from every fourth paddock should allow nearly a complete station poisoning. In this way the poisoned water need not be removed each morning but merely covered to eliminate bird or other fauna losses during daylight hours. Dams present a major difficulty. These must be fenced with strong netting or link mesh and another watering place provided nearby. This should be done at least five days before poisoning and the dam enclosure shut up each night so as to accustom the animals to drinking (or "free watering") at the new trough.

It is imperative that no non-poisoned water be available during the nights when poison is laid.

BIRD LOSSES

Preliminary tests have shown that unless the poison troughs are covered at dawn, birds will be killed. This means that each man has only sufficient time to handle approximately three mills, even if he starts half an hour before dawn. It is also important to see that no pools of poisoned water are left lying around on the ground as finches and other small birds will readily drink from these. Some owners may be inclined to float planks on the tanks in an effort to entice birds to water there. In some cases this has proved successful.

LENGTH OF POISONING SEASON

In the West Kimberley region the poisoning season extends over three months from September to December—(or until the "wet season" breaks).

It may be possible, with a tasteless poison like "1080," to open the season a little earlier. However, this may not be necessary because of the limited area involved.

This year the Agriculture Protection Board instituted a large-scale field trial in this area. Pastoralists were asked to co-operate in the trial by having as many mills as possible poisoned. "1080" was used in this work. The poison was laid by competent trained operators and pastoralists were obliged to pay the costs of the scheme. These were based on the following:—

Labour and overhead costs—£7 13s. per day.

Mileage—1s. 2d. per mile.

Poison ("1080")—7s. per vial.

Stations could use their own vehicles to transport the operator if desired.

It must be remembered that these facts and this field trial only apply to the Sandy Wallaby. Work is being undertaken along similar lines with the Marloo, or Plains Kangaroo but this is only in its infancy and it is not envisaged that it will be completed for at least another two years.

In this first year of operations three stations participated. A total of only 19 mills was made available. These were poisoned at an average costs of £9 12s. 6d. per mill. They were all poisoned using a concentration of 20 grams "1080" per 100 gallons. This amount was used in response to a request from a pastoralist who was not content to use the smaller concentration. Further experimental work later showed that 3.0 grams. per 100 gallons was sufficient to effect an excellent kill. This large-scale trial at least showed the practicability of poisoning a large area for Sandy Wallabies. One operator was able to poison these 19 mills in 12 days. Many more could have been done in the time had they been available. This, together with a reduction in poison concentration would materially reduce the cost to the pastoralist.

SUMMARY

(a) The experiments set out describe a suitable method for poisoning the Sandy Wallaby (*Macropus agilis*) in the Pindan country of the West Kimberley Region of Western Australia.

(b) The average consumption at a "first drink" for the Kimberley Wallaby was 36.2 fluid oz. (1 4/5th pints).

(c) The lethal doses of the poisons used were, "1080," 0.2 mgms./pound, and arsenic pentoxide was found to be 7.5 mgms./pound body weight.

(d) The palatabilities of arsenic pentoxide and sodium arsenite were compared, *Macropus agilis* preferring the latter.

(e) The most suitable of the arsenic pentoxide solutions used was 12 oz./100 gals. This was further checked by obtaining individual consumption figures, shown in the mortality fraction table.

(f) Various doses of "1080" were used, as little as 3 grams./100 gals. proving quite satisfactory in field tests, these results were based on quantities of poisoned water consumed but unfortunately did not include confirmatory population counts. Very few carcasses were found.

(g) Three factors are discussed which are important in the application of water poisons—

(a) The exclusion of stock.

(b) The effect on native fauna.

(c) The length of poisoning season.

(h) The first year's wholesale poisoning operations are described and costs discussed.

BLACKLEG IN CATTLE

By C. R. TOOP, B.V.Sc., Chief Veterinary Surgeon

BLACKLEG is almost essentially a disease of young cattle usually affecting animals between the age of six and 18 months. It is characterised by the development of crepitant swellings on the neck, chest, shoulders or hindquarters and sometimes on other parts of the body, and this is accompanied by symptoms of acute illness which in most cases terminates fatally after an interval of 18-36 hours.

It is caused by infection with *Clostridium chauvoei,* a short rod-shaped micro-organism or bacillus which occurs in the soil and is believed to gain entrance to the body through the digestive tract. *Clostridium chauvoei* produces spores which are able to survive in the soil for long periods. Consequently when the infection has become established on a property, outbreaks of the disease may continue to occur for many years.

Although blackleg may occur under a wide variety of conditions it is most frequently observed on moist low-lying areas. In Western Australia it is confined to the South-West coastal districts and has not been reported from the drier inland areas.

The disease may be prevented by inoculation with blackleg vaccine which confers upon the treated animals a strong and lasting immunity and is usually sufficient to protect young cattle from infection during the period when they are most susceptible.

MODE OF INFECTION

It should be recognised that blackleg does not spread directly from animal to animal but results from infection with an organism existing in the soil. The blackleg bacillus *(Clostridium chauvoei)* is always present in the soil of affected properties and so far as is known it enters the body through the digestive tract and after gaining access to the bloodstream is deposited in various tissues. Lesions in cattle are rarely associated with wounds or other injuries.

The carcass of an animal dead of blackleg contains enormous numbers of infective organisms and, should it be allowed to decompose and disintegrate in the field, gross contamination of the soil will inevitably occur.

The formation of spores, which are very resistant to extremes of temperature and drying, enables the infection to persist in the soil for many years so that after the disease has made its appearance on a property recurrent mortalities are likely to take place.

SYMPTOMS

The disease has a definite age incidence usually affecting young cattle between the age of six and 18 months. It may also be observed on occasions in calves four to six months old but seldom affects animals above the age of two years. In districts where blackleg is prevalent, cattle over three years may be regarded as immune.

The onset of the disease is sudden. The earliest symptoms consist of loss of appetite and cessation of rumination together with high fever and rapid respiration. The animal appears dull and depressed, is reluctant to move and lies down frequently. The development of swellings on the shoulder, neck, chest, thigh or flank, and sometimes elsewhere on the body is a characteristic feature of the disease and this is usually accompanied by lameness affecting the fore or hind limbs.

The swellings are at first small and tender but rapidly increase in size becoming large and extensive and non-sensitive.

Upon pressure, a peculiar crackling sound is heard due to the presence of gas beneath the skin. The gas is formed during the growth of the causal organism in the underlying tissues. Similar swellings are sometimes observed on the gums, tongue, and pharynx.

From this stage the condition of the animal rapidly deteriorates and soon it is unable to rise. Death generally occurs from 12-36 hours from the onset of symptoms and is preceded by prostration and muscular tremors.

POST-MORTEM APPEARANCES

Soon after death the carcass becomes tightly distended with gas so that the uppermost limbs may extend straight out from the body and a dark-coloured frothy discharge exudes from the mouth, nostrils and anus.

At post-mortem, the skin overlying the swelling appears dark, dry and parchment-like, and a dark frothy fluid with a sour disagreeable odour escapes when the swelling is incised. The underlying muscles are distended and are brown or black in colour and are infiltrated with bloodstained liquid and gas. Apart from the presence of fluid in the abdomen and chest cavity and some congestion of the liver and kidneys no changes of note are observed in the internal organs.

PREVENTION

Vaccination.—The disease may be prevented by inoculation with blackleg vaccine which provides the only practical and effective means of control. An injection of 5 cc. of this product given beneath the skin either in front of or behind the shoulder, results after an interval of 14 days in the development of a strong immunity which endures for 12-18 months and is therefore capable of protecting young animals from infection during the period when they are most susceptible to the disease.

In localities where the disease has a seasonal incidence, young stock should be vaccinated annually at least 14 days in advance of the period when losses are expected to occur. Where the disease occurs irregularly, calves should be vaccinated upon reaching the age of four to six months. It should be noted that blackleg vaccine is not a curative and is only of value for the prevention of the disease. When, however, the disease makes its appearance on a property, the immediate vaccination of the animals which are still healthy followed by their removal to a fresh paddock for a period of 14 days can be relied upon to check the mortality.

As a further precaution the carcass of any animal dead of blackleg should be destroyed by burning or buried deeply.

Fig. 1.—Dense pasture of barrel medic and wild oats on Roberts' Farm, Dalwallinu, September, 1956

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BARREL MEDIC FOR WHEATBELT PASTURES

Demonstrations show promise

By B. F. CARLIN, B.Sc. (Agric.),
Agricultural Adviser

INVESTIGATIONS with Barrel Medic (Medicago tribuloides) have indicated that this species has a wide range of usefulness as a leguminous pastoral plant for the heavier soils in those areas receiving less than 18 inches of rainfall annually. There has been a continued emphasis on improved pasture as the basis for better and more productive rotations and the outstanding part played by subterranean clover in utilising large areas of light sandplain in the higher rainfall districts is well known. Barrel medic (or Barrel Clover as it is sometimes called) should fill a somewhat similar position under the conditions for which it is suited.

It has a smooth burr which does not adhere readily to the wool of sheep and is a hardy plant, setting seed even in dry years, and appears to be reliable in its growth pattern.

Like other legumes it produces high quality feed and is palatable to stock. Hay made from a mixture of barrel medic and oats in the Waddi Forest district in 1956 gave an analysis of 16.1 per cent. protein.

Barrel medic and Wimmera ryegrass make a good pasture mixture, and in areas where commercial ryegrass does not mature freely, the early strain of ryegrass should be used.

The recommended seeding rates are 2 to 4 lb. of barrel medic and 1 lb. of Wimmera ryegrass per acre. On old land which previously had received substantial applications of phosphatic fertilisers 90 to 112 lb. of superphosphate would be a suitable application when planting. If the inoculated seed is to be mixed with the fertiliser, basic superphosphate at a rate of 100 to 130 lb. per acre should be used.

Before sowing, the barrel medic seed should be inoculated with the correct strain of rhizobial bacteria. The sowing should be made into a moist seed-bed as soon as possible after the inoculation, and inoculated seed should never be exposed to sunlight for any length of time as this will kill the bacteria.

DEMONSTRATION PLOTS

A number of barrel medic demonstration plots have been established by the Department of Agriculture during the past three seasons and those to the north and east of Moora have given very encouraging results. Some aspects of these plots are shown in the photographs accompanying this article. The diagram shows the general layout of the plots.

It will be seen that cross-treatments were used to check the effect of trace elements but no response to trace ele-

BARREL MEDIC DEMONSTRATION PLOTS

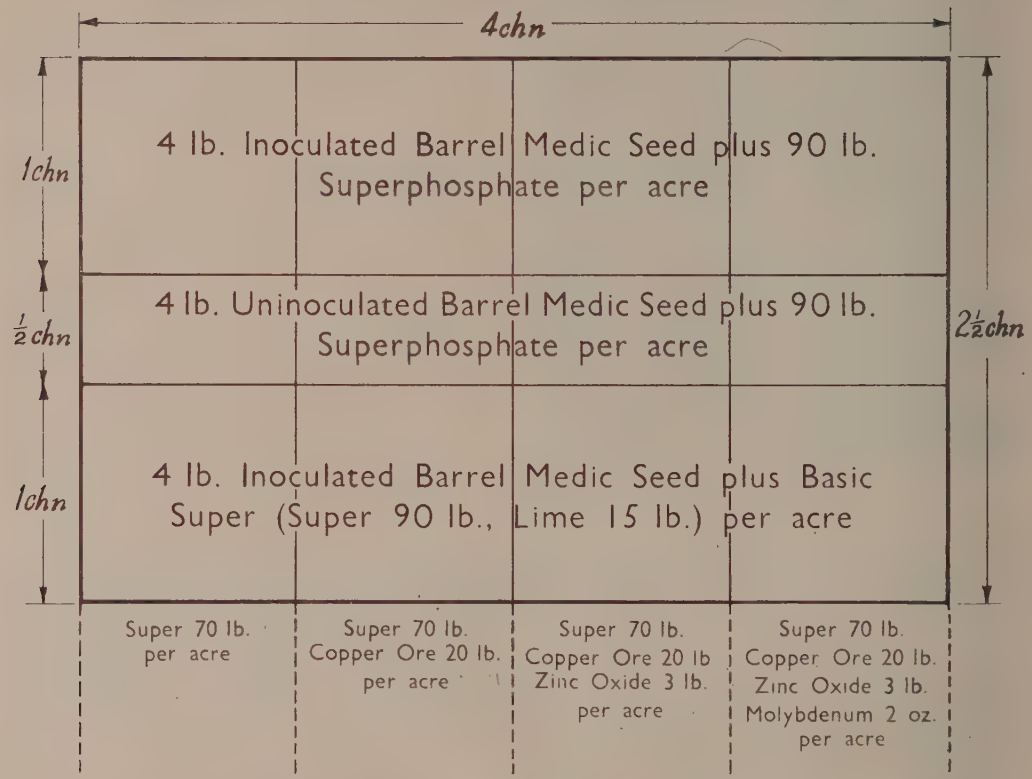
4chn
1chn
½chn
1chn
2½chn
4 lb. Inoculated Barrel Medic Seed plus 90 lb. Superphosphate per acre
4 lb. Uninoculated Barrel Medic Seed plus 90 lb. Superphosphate per acre
4 lb. Inoculated Barrel Medic Seed plus Basic Super (Super 90 lb., Lime 15 lb.) per acre
Super 70 lb. per acre
Super 70 lb. Copper Ore 20 lb. per acre
Super 70 lb. Copper Ore 20 lb Zinc Oxide 3 lb. per acre
Super 70 lb. Copper Ore 20 lb. Zinc Oxide 3 lb. Molybdenum 2 oz. per acre

Fig. 2.—Heavy second-year stand of barrel medic on F. Fowler's property, Bolgart, 1955

Fig. 3.—Barrel Medic Demonstration, W. L. Broadhurst, Burakin, 1957
Left—Inoculated seed and basic super
Right — Uninoculated seed and super

ments has been observed in plots sown in the Moora district.

In June, 1955, one of these demonstration plots was sown on Roberts Farm one mile south of Dalwallinu on the Great Northern Highway. The land originally carried salmon-gum and morrel. Barrel medic has done well over the whole of the plot during 1955, 1956 and 1957.

In late May, 1956, a similar plot was sown on Mr. W. L. Broadhurst's property, two miles north of Kirwan on the Kirwan-Burakin road.

This land originally carried salmon-gum. Although the spring of 1956 was very dry the barrel medic seeded down and re-established well in 1957. The response to inoculation was much more marked here than at Dalwallinu and in 1957—as the photograph shows—there was little growth on the uninoculated strip. Basic super also gave a response on this plot.

In July, 1957, a further area was sown on Mr. R. N. Tonkin's property, one mile south of Coomberdale on the Geraldton

Fig. 4.—Barrel Medic Demonstration, R. N. Tonkin, Coomberdale. Sown July 1957, and photographed October 15, 1957

Highway. This land was also salmon-gum country and although the 1957 spring weather was by no means ideal and the planting was somewhat late, the plants made good growth and seeded heavily.

The demonstration plots have shown that barrel medic offers scope for pasture improvement on heavy land in the wheatbelt if planted according to Department of Agriculture recommendations.

FARMERS

This is YOUR Journal, and it has been written, edited and presented in a sincere endeavour to give you helpful information in an interesting manner.

We would like to have your views on the Journal—to know whether you like it or whether you don't. Drop a line to the editor and tell him the features you like and don't like in this issue—or the features you hope to see in future issues.

MURESK AGRICULTURAL COLLEGE

(Department of Agriculture)

Parents are reminded that applications for 1959 admission to Muresk Agricultural College close on 31st December of this year. A preliminary selection of 1959 entrants is made after the Junior results are available in January, 1958.

The successful applicants then continue with Sub-Leaving studies during 1958.

The Entrance qualifications include:—

(a) Sub-Leaving English, Mathematics A, Physics (including Magnetism and Electricity), and Chemistry.

(b) Junior Bookkeeping.

Should places still exist after the preliminary selection qualified applicants are enrolled in the order of application.

DURATION OF COURSE—Two years.

FEES—Approximately £130 per annum covering full residential charges.

SCHOLARSHIPS—Department of Agriculture (3), the "Countryman," and J. J. Poynton Memorial (2).

BOARDING ALLOWANCE—Most Muresk students are eligible for the Education Department Boarding Allowance (£50 per annum).

Full details of the College are obtainable from the Principal, Muresk Agricultural College, Muresk, W.A., or the Department of Agriculture, Perth.

INSECT Pests AND THEIR CONTROL

By G. D. RIMES, B.Sc., Entomologist

WAX MOTH—An apiary problem

THE damage to honeycomb caused by wax moth is a world-wide problem, the extensive distribution of the pest being due to the transport of infected material which has accompanied the expansion of bee-keeping. Although wax moth can be reared on a variety of materials not obtainable in the beehive, their association with the honey-bee is of such antiquity, that honeycomb in one form or another now forms its only natural food supply.

Wax moth is a pest to most bee-keepers at various times of the year, whether in weak colonies or in stored honey combs. Although in the active hive very little damage, if any, can be caused by the wax moth, a weak colony can suffer a severe set-back by the damage to the brood. However, it is the stored comb that is the real habitat of the pest, and it is mainly with the storage problem that this article is concerned. Insecticidal treatment of an infested hive is not possible even with the selectivity of present day insecticides. There is a belief that wax moth can combat foul brood, but this is incorrect.

There are two species of moths that cause trouble in Western Australia—the Greater Wax Moth, *Galleria mellonella* (L) and the Lesser Wax Moth *Achroia grisella* (F). Both are fawn-coloured moths, the difference to casual observation being size, the Greater Wax Moth having a wing span of approximately 1¼ in., the Lesser Wax Moth being approximately ¾ in. The life history, habitat and significance of both, is similar.

The eggs are laid in cracks in the comb frame, irregularities in the super, or in litter on the hive floor. Vast numbers of eggs, barely visible to the eye, are laid, some reports placing the number as high as 1,500 per female. These hatch in one to five weeks, depending on the seasonal temperature. Warm summer temperatures can shorten the incubation period to five days. The larvae then make for the midrib of the honeycomb, damaging cells on each side as they travel. The tunnels thus formed are lined with silken thread and show up clearly in frames when held to the light. They may also connect frames together with their silken web. The temperature most favourable for their development is 90° F. and at this temperature, the larval life is about one month. This may extend up to five months if temperature and food supply are unfavourable.

The food material consists mainly of cocoon debris and other impurities in the wax. It is impossible to rear wax moth in pure foundation wax.

When fully developed the larva prepares a depression in the woodwork and then spins a whitish cocoon in which it undergoes metamorphosis. This depression can be anything up to ⅛ in. deep, and repeated infestations can seriously

weaken a hive structure. The cocoon stage occupies from one to eight weeks, depending on temperature. With several life cycles completed in a short period, severe infestation can result in complete destruction of the honeycomb, all that remains being a tangled mass of web, with the frames securely stuck together and to the box. The severity of damage depends on the existing temperature and food supply. Techniques which are suitable for storage in a cold area are entirely unsatisfactory in warmer climates.

Fig. 1.—Frames of honeycomb showing wax moth damage

Control of wax moth is directed at satisfactory storage and fumigation techniques, the only control in the apiary being to preserve strong colonies and to use well-fitting lids and boxes.

STORAGE TECHNIQUES

Para-dichlor-benzene.

The most common way of storing honeycomb is with para-dichlor-benzene in the comb-cupboard. Para-dichlor-benzene is a white crystalline solid which slowly gives off a vapour toxic to wax moth. The comb-cupboard is generally at fault in this technique. Suitably airtight doors must be used and the whole structure must be proof against wax moth entry. Periodical inspection and renewal of fumigant is necessary if success is to be achieved. At least monthly investigation is necessary.

It is possible to dispense with the comb-cupboard and stack honeycombs in their boxes. The joints between boxes must be sealed. Approximately ½ oz. of fumigant should be placed on a piece of paper or card on the top of each box. Once more, periodical inspection must be carried out if any success is to be obtained.

One reason for the failure of these techniques is the fact that the temperature necessary for para-dichlor-benzene to vaporise must be 70° F., or more. At lower temperature the material is inoperative.

Sulphur Dioxide.

This is the pungent asphyxiating gas liberated when sulphur is burnt. This gas is very effective in killing the various stages of the life cycle of wax moth. It is produced by sprinkling sulphur over coals in a small brazier. The technique can be used in stacked boxes, suitably sealed, with the bottom box empty, a fireproof baseboard being necessary.

However, the most satisfactory way of using this material is with an airtight fumigation chamber or tank. In this way complete protection can be obtained with periodical fumigation. With experience, inspection can be eliminated, and comb stored throughout the danger period without risk.

Cyanide.

Cyanide fumigation is perhaps the most dangerous of all fumigation techniques. Commonly called prussic acid, the fumes are highly toxic to man, and to keep the solid cyanogas or calcium cyanide on hand is unwise as there is always the risk of accidental poisoning with children.

The cyanogas will slowly break down when exposed to the atmosphere and liberate the fumigant. Fumigation can be done either in a chamber, or with stacks of boxes, the fumigant being placed at

the bottom of the stack, at the rate of ½ oz. per box. Care must be taken to seal the joints of the boxes.

Carbon Bisulphide.

This liquid gives off a heavy toxic vapour which is very effective against various stages of wax moth. Honeycomb can be safely stored in a fumigation chamber with this compound, at the rate of 4 lb per 1,000 cu. ft. It is possible to fumigate stacked boxes in the open with the fumigant placed in a shallow tray in an empty box, on top of the stack, at the rate of ¼ oz. per box. The stack should be carefully sealed.

Carbon bisulphide is an extremely dangerous substance to handle. If forms explosive mixtures with air which can be set off by such temperatures as that of a steam pipe or an electric light bulb.

SOME NEW TECHNIQUES

In view of the undesirable characteristics of the above fumigants, work has been carried out by the Department of Agriculture in the past two years to enable improved storage of honeycomb. The important aspect of this work being the provision of an easily-handled fumigant, and one that does not possess a residual effect harmful to bees or honey.

Carbon Bisulphide and Carbon Tetrachloride.

Carbon bisulphide is an efficient fumigant, the only drawback being its inflammability and explosive properties. When mixed with carbon tetrachloride in the ratio of 1 to 4, it loses both these properties. Carbon tetrachloride also has some fumigatory action of its own.

The frames of honeycomb from 20 supers were weighed, and half of these were fumigated with the above mixture and half were stored without fumigation. The mixture was used at the rate of 20 lb. per 1,000 cu. ft. After 48 hours, the supers were removed and placed in a shed where the air was kept in circulation. After airing for 24 hours, four boxes of frames were made up, alternating four fumigated and four non-fumigated frames per box. These four boxes were placed out on four hives at the Departmental Apiary, Yanchep

A second batch of four boxes was placed out after one week's airing, being composed of half fumigated and half non-fumigated frames, alternating. This was repeated after 2, 3, and 4 week's airing, the aim being to determine the period necessary, if any, to remove odour repugnant to bees.

Each batch of frames was left on the hives for one month. At the end of this period, the frames were weighed and the honey yield from each determined. Comparisons were then made between fumigated and non-fumigated combs, and between the various periods of airing following fumigation. The statistical analysis showed no significant difference between treatments.

Another batch of frames was kept in the fumigation chamber, using the above fumigant, from August 15, 1957, until October 14, 1957. They were removed three hours prior to placing on hives, fumigated and non-fumigated frames being alternated in the boxes. Honey yield

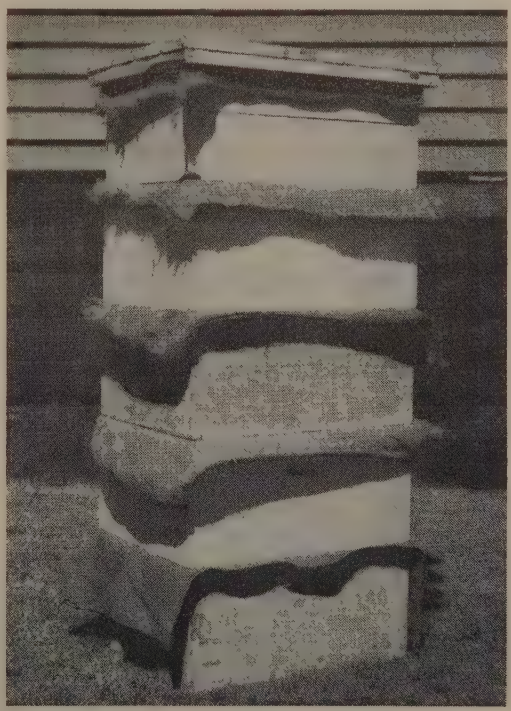

Fig. 2.—Supers of honeycomb undergoing fumigation with ethylene di bromide

was determined after one month and a statistical analysis of the results carried out. No significant difference between treated and untreated combs was found.

Conclusion.—The carbon bisulphide-carbon tetrachloride mixture has been demonstrated to be completely free from any repugnance to bees or tainting effect on the honey yield. Such a mixture can be used in fumigation chambers at the rate of 20 lb. per 1,000 cu. ft. or in small stacks of boxes, sealed together and the fumigant placed in a shallow tray, at the rate of one ounce per box, in the top box. The mixture consists of one volume of carbon bisulphide added to four volumes of carbon tetrachloride.

Ethylene di Bromide.

A further series of experiments was carried out to determine the suitability of the above fumigant for honeycomb fumigation. Boxes of frames were stacked with a piece of sacking between each, finely sprinkled with ½ oz. of ethylene di bromide. These were made up into boxes containing half fumigated, and half non-fumigated frames, and placed out on the hives. They were aired for three hours following fumigation. The honey yield per frame was determined after one month, and an analysis of the figures performed. No significant difference between fumigated and non-fumigated frames was found. There was no trace of taint in the honey yield.

Frames were kept in the above manner for periods of up to five months without wax moth damage, although activity of the moth was high.

Conclusion.—Ethylene di bromide has been demonstrated to give protection against wax moth, when sprinkled on sacking placed between boxes of frames. One ½ oz. per box, with monthly renewal of fumigant is necessary. Ethylene di bromide is a slowly evaporating liquid, and in colder areas bi-monthly renewal would be sufficient.

Acetic Acid.

Research work carried out at Rothamsted experimental station in 1954, on *Nosema* disease, led to the findings that control of wax moth could be obtained by the fumes of glacial acetic acid. Reporting this work C. G. Butler (1955) states, "It has been observed by L. Bailey that infestation by the Lesser Wax Moth (*Achroia grisella*) was eliminated in combs which were fumigated with acetic acid vapour for the control of *Nosema* and *Amoeba* diseases. Adult and larval wax moths were killed within 24 hours. Some fumigation experiments with the eggs of the Greater Wax Moth (*Galleria mellonella*) and of the Lesser Wax Moth showed that they were killed after exposure to acetic acid fumes for 12 to 24 hours at 59° F."

Trials carried out at the Department of Agriculture apiary, Yanchep, have shown that boxes of honeycomb can be fumigated and stored in stacks with a shallow tray of 80 per cent. acetic acid in the bottom box. One half pint was required for five boxes of frames. The boxes were sealed together at the joints with an adhesive tape. Periodic inspection and renewal of the acid is required. This technique has the added advantage of providing a degree of protection against *Nosema* (C. G. Butler, 1955.)

REFERENCE

Butler, C. G. (1955), Report Rothamstead Expt. Station.

ARE YOU ON OUR MAILING LIST?

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Fig. 1.—Acute copper deficiency in wheat. Note the death of terminal shoots with accompanying whitening and twisting of the leaves

The Use of Copper and Zinc in the Cereal-Growing Districts of Western Australia

By J. TOMS, B.Sc. (Agric.), Plant Research Division

FERTILISERS containing small quantities of copper and zinc are widely used for crops and pastures in Western Australia, and the benefits resulting from the use of one or both of these trace elements—especially on sandy or gravelly soils—have been demonstrated in numerous trials during the past 20 years. It is estimated that about 5,000,000 acres have been treated with copper and zinc in Western Australia in the ten-year period 1947-1956. In this article, an attempt has been made to answer some of the common inquiries made by farmers concerning the use of copper and zinc in cereal-growing districts where large areas of light land are being developed.

Application of copper and zinc to all light land is a sound policy. In most cases it will result in marked improvements in crop yields and pasture growth, and even where no spectacular plant growth responses are obtained, there will usually be improvements in animal health.

WHAT SOILS ARE DEFICIENT IN COPPER AND ZINC?

In general, it is advisable to apply both copper and zinc to the first crop grown on any land with a sandy or gravelly surface.

Soils with such "light" surface characteristics carry a wide range of native vegetation, e.g., the mallees, low scrub and tussocks, the wodgil association, blackboy, red gum, wandoo, jarrah, blackbutt and tamma are all found on soils of sandy or gravelly surface.

All such soils have low copper and zinc content, but in some areas little or no crop response is obtained from copper and zinc fertilisers. These areas, however, are not extensive and the pasture growing on them is generally too deficient in copper for stock to attain perfect health. Also such soils often require addition of zinc when oats are grown.

It is therefore, advisable to apply copper and zinc to all soils of light surface.

Copper should also be applied to all soils in the Gingin and Dandaragan areas.

Even heavy soils in these districts are acutely copper-deficient.

Oats sometimes show zinc deficiency on heavier soils but only on small areas which have been made alkaline by the burning of heaps of stumps or brush. On the alkaline "puffs" of some heavy "crab-hole" soils, zinc deficiency in oats may also occur.

Fig. 2.—Mild copper deficiency in wheat. Note the bent stems and ears. The straw has been weakened, but there has been little reduction in grain production. The weight of the grain has resulted in the bending of the weak straw

HOW ARE THE DEFICIENCIES RECOGNISED ON CEREALS?

Copper deficiency affects wheat, barley and oats, but on similar soils cereal rye grows normally.

Wheat is more susceptible than barley, which in turn is more susceptible than oats.

The symptoms are best seen on wheat, but are similar for wheat, oats and barley.

With mild copper deficiency on wheat, symptoms are seldom seen till the crop is nearly mature. The straw is weakened but a considerable quantity of grain is formed. This causes the weight of the ear to bend the stem often to such an extent that the ear points to the ground (see Fig. 2). When the deficiency is as mild as this, yields may be only slightly increased by addition of copper fertiliser.

When the deficiency is more pronounced, ears form but little or no grain is set. If some grain is produced it is shrivelled. The stem is weak but as it carries no grain it is able to bear the ear erect. These dummy heads

Fig. 3.—Effect of copper deficiency on wheat straw colour. The plot in the middle has not received copper and is much darker than the crop on the extreme left and right which has received copper. This darker colour is sometimes due to the greater incidence of septoria on the copper deficient plants

are often referred to as "whiteheads," but in actual fact they are more often straw-coloured. (Similar "whiteheads" can often be caused by drought or frost). The last leaves to form on the stem often die from the tip backwards, the leaf whitening, twisting and fraying in the process.

When the deficiency is acute, symptoms can show up early in the growing period. The whole terminal shoot dies, whitens and twists (see Fig. 1). Under such circumstances ears do not usually form.

in colour while neighbouring plants receiving copper fertiliser are hardly affected.

Copper-deficient plants are very sensitive to drought, because of poorer root growth and reduced ability to retain water.

It is interesting that although oats are less sensitive than wheat to copper deficiency they normally contain a greater quantity of this element. Oats evidently are more efficient than wheat in removing copper from the soil. (Similarly,

Fig. 4.—Zinc deficiency on oats. Note the death of the older leaves with accompanying twisting and blackening. Often a range of colours from black to red to orange to yellow to green is visible along an affected leaf

Secondary tillering—the growth of new shoots at the base of the plants—is a characteristic of acutely copper-deficient plants. These secondary tillers become affected like the older growth and their terminal shoots also die, whiten and twist. Thus a plant is produced with a large number of tillers, few or none of which produce ears. Some secondary tillering can also occur on plants less acutely affected by copper deficiency.

The maturity of copper deficient plants is often delayed.

The straw of copper-deficient plants is darker in colour than that of healthy plants.

Copper-deficient plants are more susceptible to "foot rot," "root rot," and septoria attack. Attack by septoria can often be severe enough on copper-deficient plants to cause the straw to be dark grey

wheat contains more zinc than oats, yet responses to zinc are more frequent with oats than wheat.)

Copper deficiency is difficult to recognise in barley or oats unless it is acute. Grain yields can be reduced, and yet there may be no obvious symptoms. When the deficiency is acute, the same symptoms are exhibited as are shown by wheat.

Zinc deficiency mainly affects oats, which are far more susceptible than wheat or barley.

The first signs of the deficiency can occur early in the growing season. In succession the oldest leaves turn a black or grey-black colour, the colour change commencing at the leaf tip and gradually extending until the whole leaf is affected. Multi-colour changes down the leaf are often apparent (see Fig 4). A full range of colours from the leaf tip would be

black, red, orange, yellow and normal green at the base. Often some of these colours are absent, e.g., red and yellow stages may not be apparent, while sometimes the black grades sharply to normal green. The blackened area twists from the tip downwards as the blackening extends. Growth of the plant is arrested and maturity delayed. At maturity the straw is grey in colour, and is easily distinguished from straw of healthy plants.

Some recovery is often made by deficient plants towards the end of the growing season, and reasonable crops are sometimes produced.

centre with accompanying death of affected tissue. Older leaves were first affected. As this symptom rarely appears in the field it is of little importance to farmers.

HAVE THERE BEEN ENOUGH EXPERIMENTS WITH COPPER AND ZINC TO DEMONSTRATE THE NEED FOR GENERAL APPLICATION ON LIGHT LAND?

The Tables 1 and 2 show the general results of experiments carried out in the Western Australian wheatbelt for the period 1953-1956 inclusive.

SUMMARY OF RESULTS OF COPPER AND ZINC EXPERIMENTS ON LIGHT LAND IN THE WESTERN AUSTRALIAN WHEATBELT IN THE YEARS 1953-1956 INCLUSIVE

Table 1

Effects of Copper and Zinc applied separately

	WHEAT		OATS	
	Number of Experiments	Average effect on yield at each site in bushels per acre	Number of Experiments	Average effect on yield at each site in bushels per acre
Total number of experiments from which the data were drawn	43	....	25	..
Experiments showing no effect of copper or zinc alone or in combination	14	....	7	..
Experiments showing yield increase with zinc application (no copper applied)	8	1⅔	9	5½
Experiments showing yield increase with copper application (no zinc applied)	25	4	7	3
Experiments showing yield reduction with zinc application (no copper applied)	7	–4	*1	–3

* This reduction was due to shedding of grain on the earlier maturing zinc treated plots before it was convenient to harvest the experiment.

All yield differences used in this table are significant at the 5 per cent. level.

For barley and wheat, symptoms of zinc deficiency have not been clearly demonstrated. Large yield increases have never been obtained with zinc on wheat or barley except on coastal limestone soils. In one experiment, however, definite symptoms occurred on wheat plants not receiving zinc fertiliser.

Longitudinal yellow strips appeared, one each side of the leaf between the margin and centre. These eventually extended to the leaf edge and then into the leaf

Data in Table 2 were drawn from all experiments in Table 1 in which copper and zinc were applied together.

Recommendations for copper and zinc application have been based on earlier work, but the experiments carried out in the 1953-1956 period demonstrate the general results that may be expected from using copper and zinc on light land in the cereal growing districts. All these experiments were carried out on light land, where responses to copper and zinc could

SUMMARY OF RESULTS OF COPPER AND ZINC EXPERIMENTS ON LIGHT LAND IN THE WESTERN AUSTRALIAN WHEATBELT IN THE YEARS 1953-1956 INCLUSIVE

Table 2

Effects of Copper and Zinc applied together

	WHEAT		OATS	
	Number of Experiments	Average effect on yield at each site in bushels per acre	Number of Experiments	Average effect on yield at each site in bushels per acre
Total number of experiments from which the data were drawn	38	....	25	....
Experiments showing no effect of copper and zinc applied together	15	....	8	....
Experiments showing a yield increase with copper and zinc applied together	22	4	16	5½
Experiments showing a yield reduction with copper and zinc applied together	....	....	*1	–3

* This reduction was due to shedding of grain on the earlier maturing zinc treated plots before it was convenient to harvest the experiment.

All yield differences used in this table are significant at the 5 per cent. level.

be expected. It is seen that in quite a number of experiments no response was obtained to copper or zinc. In some cases this has been due to the poor season or to shedding of oats on plots receiving zinc (earlier maturity).

It can be seen from Table 1 that:—

1. Wheat responds mainly to copper application.

2. Oats respond mainly to zinc application.

3. Wheat can respond to zinc, and oats can respond to copper.

4. Reductions in yield can often be expected when zinc is applied to wheat without the application of copper at the same time. This rarely occurs with oats.

As both wheat and oats can benefit from copper and zinc, the use of both in fertilisers on new light land is recommended rather than applying copper to wheat and zinc to oats. If both wheat and oats are grown in a rotation, necessitating the application of both copper and zinc, one fertiliser mixing charge is avoided by applying copper and zinc together, rather than in separate years. Also, subter-

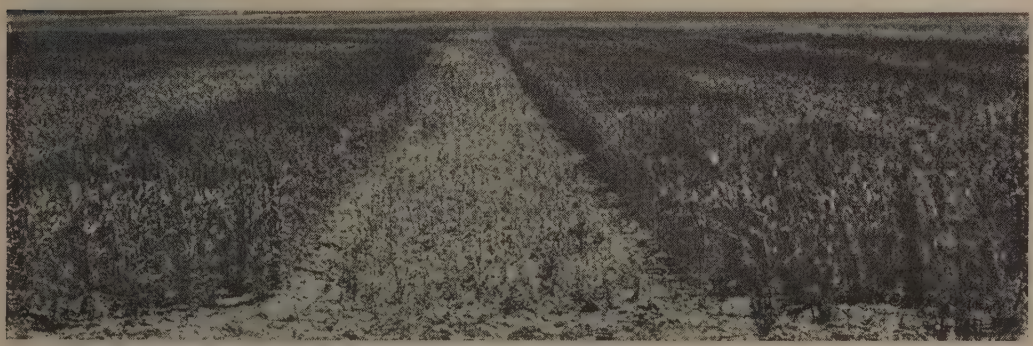

Fig. 5.—Effect of zinc on a wheat crop. The centre plot has received zinc and no copper. The plot on the left received both copper and zinc. The plot on the right received copper only. This antagonistic effect of zinc on copper uptake often occurs

Fig. 6.—Effect of zinc on oat maturity. The plot on the left has received zinc and is more mature than the plot on the right that has not received zinc

ranean clover often responds to zinc and copper application, while copper is often of advantage for stock health. Copper and zinc may therefore be of great value for the pasture in following years and for improving stock health. It is therefore always advisable to apply both copper and zinc to new light land.

AT WHAT RATES SHOULD COPPER AND ZINC BE APPLIED?

This question is very difficult to answer, and only general recommendations can be made. Optimum rates of application vary appreciably for different soils and different seasons. Any general recommendation must be suitable for land acutely deficient in copper or zinc as well as land where only small responses are obtained. The recommended rates have therefore been made ample for most districts but low enough so that toxicity does not occur. Now that oxidised copper ore is used in fertilisers instead of copper sulphate, toxicity is not likely.

The recommended rate of application has been two-thirds of a bag (120 lb.) to one bag (187 lb.) of copper-zinc-superphosphate to the acre. This supplied approximately 20 to 30 lb. of copper ore (6 per cent. copper) and 2 to 3 lb. of zinc oxide (71 per cent. zinc).

On new land a bag to the acre of the mixture should be used as this supplies 150 lb. of superphosphate to the acre. As practically all new light land is phosphorus-deficient a dressing of at least 150 lb. of superphosphate to the acre is generally recommended.

Recently the fertiliser companies have increased the copper content of the copper ore to 7 per cent. at no extra charge. This could benefit stock and increase the residual value (the time this one application will continue to give responses) of the application, but is unlikely to benefit cereals as the previous recommendation was adequate for most areas.

Recent work (1955) showed that wheat at Esperance required no more than 1 lb. 13 oz. of copper sulphate to the acre (equivalent to 6½ lb. of 7 per cent. copper ore), and wheat at Newdegate required no more than 20 lb. of 6 per cent. ore (the lowest rate tried).

Further experiments on rates of copper and zinc are now in progress at Newdegate and Hyden.

HOW OFTEN SHOULD THESE FERTILISERS BE APPLIED?

It has not yet been shown that a second application of copper and zinc is required on the deficient coarse-textured soils of the major part of the wheatbelt. A second application of copper would be advisable on copper-deficient limestone soils as at Dongara or the deficient soils at Bremer Bay, while at Dandaragan and Gingin repeated dressings are often required. These areas, however, are not large.

Plain superphosphate made in Western Australia has appreciable amounts of copper and zinc in it as an impurity. The application of 100 lb. of superphosphate to the acre will supply as much zinc and more copper than that removed from the farm in the grain of a good crop. As copper and zinc tend to be held in the soil against leaching it is probable that it would be many years, if ever, before the soil copper and zinc was reduced to a deficient level once the original deficiency has been corrected by application of copper and zinc. Previous experiments have shown that this residual effect has lasted at least five years.

IS THE USE OF COPPER AND ZINC ECONOMICAL?

One bag of copper-zinc-superphosphate costs just over 12s. more than the amount of superphosphate it contains.

Therefore, to use this fertiliser at recomended rates the cost is not small, but for this outlay a farmer will probably:—

1. Receive at least an equivalent return from the increase in yield of the first crop.

2. Obtain increases in yield of subsequent crops due both to residual value of the initial dressing and the better growth of pasture during the ley period.

3. Gain from improved subsequent pasture growth and animal health.

There is some variation from district to district but, in general, farmers cannot afford to farm light land without the application of copper and zinc.

In the main cereal-growing districts the Department has advisers of the Wheat and Sheep Division stationed at Geraldton, Moora, Northam, Narrogin, Katanning and Mt. Barker. (Their names are listed in the front pages of the Journal of Agriculture). These officers know the various districts intimately and have been trained to identify crop deficiencies. If you have any doubts about the use of copper and zinc write or telephone them and they will answer your queries. If necessary, they will arrange to visit your farm.

Use your advisers. Their services are free.

Fig. 7.—Effect of zinc deficiency on oat straw colour. The centre plot received zinc and the straw is much brighter in colour than on those plots to the left and right which did not receive zinc

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Fig. 1.—A heifer suffering from cobalt deficiency

COBALT DEFICIENCY OF STOCK IN THE BUSSELTON-AUGUSTA REGION

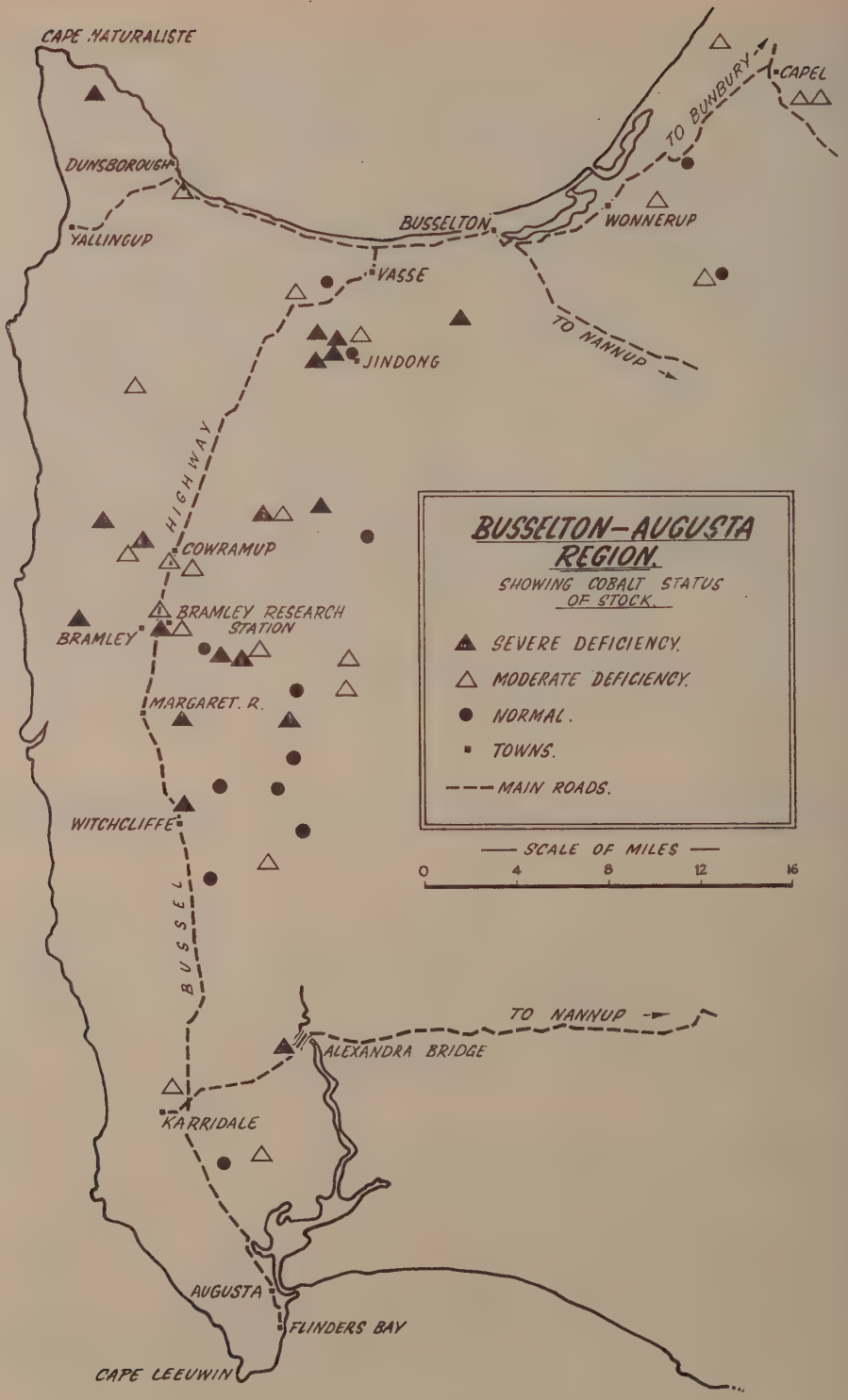
By R. HARLEY[1] and A. B. BECK[2]

DURING the past decade evidence has accumulated which indicates that large areas of country south of Busselton are deficient in cobalt. This information has been spread verbally by officers of the Department of Agriculture through personal contacts and at field days, but so far no information has been published concerning the extent and degree of the deficiency. The purpose of this article is to place on record the clinical and chemical investigations carried out since 1944.

Cobalt deficiency in Western Australia was first confirmed by Underwood and Filmer in 1935, in ruminants grazing on the karri soils of the Denmark area. Subsequent investigations carried out by the Veterinary Branch of the Department of Agriculture showed that clinical evidence of deficiency could be found in cattle and sheep grazing on the shelly sand-hill soils along the coast from Broom to Esperance. It was also found that the banksia-tuart sands inland from the west coast are deficient in cobalt to a variable degree. In some places (e.g. Muchea and Maida Vale) severe symptoms have been seen in stock, but in other places only a moderate deficiency appears to exist.

In the extreme South-West the first indications of possible cobalt deficiency were obtained in 1943 during the investi-

[1] Veterinary Officer, Department of Agriculture, Bunbury.
[2] Senior Research Officer, Division of Animal Health and Production, C.S.I.R.O., stationed at Animal Health and Nutrition Laboratory, Nedlands.


CAPE NATURALISTE
DUNSBOROUGH
YALLINGUP
BUSSELTON
TO BUNBURY
CAPEL
WONNERUP
VASSE
TO NANNUP
JINDONG
HIGHWAY
COWRAMUP
BRAMLEY RESEARCH STATION
BRAMLEY
MARGARET. R.
WITCHCLIFFE
BUSSELL
TO NANNUP
ALEXANDRA BRIDGE
KARRIDALE
AUGUSTA
FLINDERS BAY
CAPE LEEUWIN
BUSSELTON–AUGUSTA REGION.
SHOWING COBALT STATUS OF STOCK.
SEVERE DEFICIENCY.
MODERATE DEFICIENCY.
NORMAL.
TOWNS.
MAIN ROADS.
SCALE OF MILES
0
4
8
12
16

gation of copper deficiency in cattle and sheep. In experimental animals no symptoms of cobalt deficiency were noted, although low levels of cobalt were found in livers of some of the animals. Subsequent clinical observations in the field indicated a cobalt deficiency throughout the region. This deficiency has been confirmed both by chemical analysis of liver samples and by the response to cobalt feeding. Such confirmation is essential because the symptoms of cobalt deficiency, particularly in mild cases, are not sufficiently characteristic to enable the establishment of a firm diagnosis. During recent years clinical evidence of cobalt deficiency appears to have increased throughout the region.

The data have been summarised in the accompanying map. The results of chemical analyses have been used to grade the degree of the deficiency although there has not always been the expected correlation with clinical signs. Generally a "severe deficiency" rating indicates obvious symptoms in stock such as wasting in both sheep and cattle and rheumy eyes in sheep. In the case of "moderate deficiency" there may be no symptoms definitely indicating deficiency disease but the growth of young stock is retarded, adult cattle do not thrive and animals improve when cobalt is supplied.

In some instances copper deficiency has also been encountered but, generally speaking, copper-containing fertilisers have been used throughout the region, which is known to be severely deficient in copper.

DISCUSSION OF RESULTS

It will be seen that evidence of both severe and moderate deficiency has been encountered over a very wide area. As the soil types are similar throughout the region, it is probable that the whole belt of country from Cape Naturaliste to Cape Leeuwin is deficient in cobalt. It is not known how far eastward this belt extends but symptoms have been observed in stock for at least three miles east of the Bussell Highway.

In some areas of severe deficiency (e.g. west and north-west of Margaret River) the soil types are apparently derived from

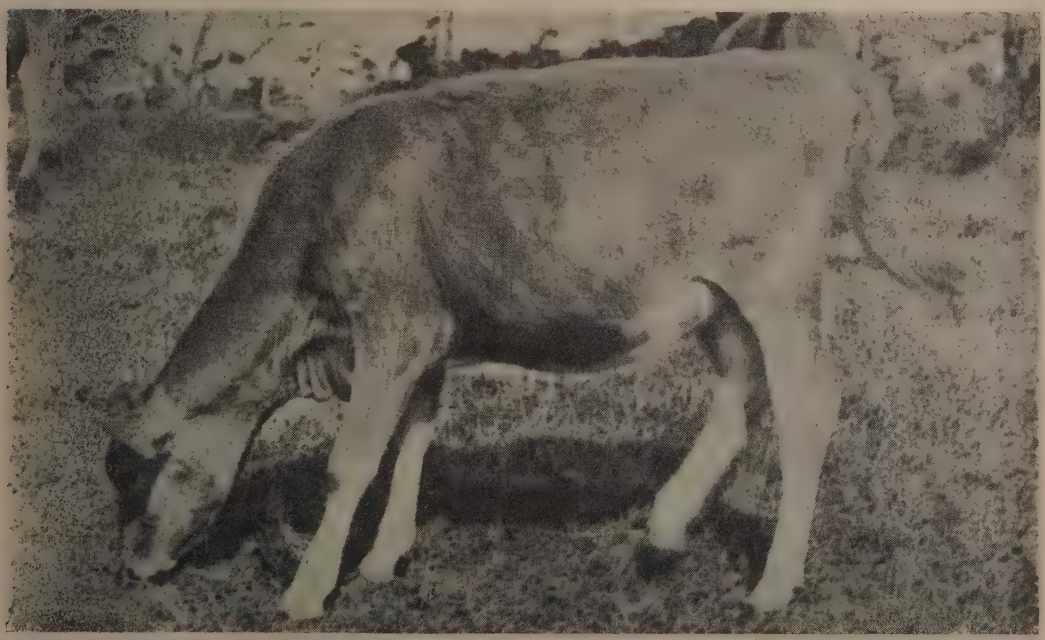


Fig. 2.—The same heifer showing improvement in condition, following upon cobalt supplementation

Fig. 3.—Sheep suffering from cobalt deficiency

shelly sand-hills nearer the sea where "coast disease" has been known for many years. Many other properties are on light sandy soil types which might be expected to be deficient even though similar soils inland do not appear to show cobalt deficiency. One surprising feature of these investigations is that the deficiency has been observed on ironstone gravel soils (laterites). Hitherto it was thought that such soils would contain adequate cobalt. It is not known whether the levels of cobalt are low in the lateritic soils of this region or whether it is present but not available to pasture plants. Recently, cobalt deficiency has been confirmed in stock grazing on some lateritic soils of the Darling Ranges and it is possible that other similar soils elsewhere may be found to be deficient.

Although no controlled experiments have been made in the Busselton-Augusta region, beneficial results have been claimed where cobalt has been used. At the Bramley Research Station some heifers were placed on pasture which, although severely deficient in copper, had been topdressed with cobalt suphate only; other heifers of the same age were run on the paddocks which, at that time, had received copper fertiliser but no cobalt. In spite of a very low intake of copper, the animals on the cobalt-treated paddocks were judged, for at least the first 18 months, to show much better growth and condition than those receiving no cobalt. Subsequent treatment of all paddocks with cobalt has resulted in an evident improvement in the condition of all stock.

RECOMMENDATIONS

It is recommended that the cobalt status of all country extending between Cape Leeuwin and Cape Naturaliste and inland to three miles east of the Bussell Highway should be regarded as marginal.

The symptoms of cobalt deficiency in stock have been described in Departmental Bulletins 2172 and 2227 but certain diagnosis is not easy. Very mild cases may pass unnoticed, and other diseases may give symptoms identical with those of moderate to severe cobalt deficiency. Farmers who suspect that their properties are deficient in cobalt should contact the Veterinary Office, Department of Agriculture, Bunbury.

At present the easiest method of preventing the deficiency disease in cattle and sheep is to topdress with cobalt-

containing fertilisers or to spray pastures with an equivalent amount of cobalt sulphate or chloride solution. Topdressing will probably not be effective on soils containing shell fragments. Details of topdressing and other methods are given in the previously mentioned Bulletins. It should be pointed out that, although simple, topdressing of pastures is an exceedingly wasteful method for supplying cobalt to stock. Only a very small fraction of the cobalt applied becomes available to the animals because of the low degree of absorption of cobalt from the soil by pasture plants. The newly developed cobalt "bullets" will probably prove to be the most economical method for supplying the element to sheep. These "bullets" have not yet been used commercially on cattle.

TECHNICAL APPENDIX

Cobalt was estimated in liver samples by the nitroso-R-salt method of Marston and Dewey (Aust. J. exp. Biol. & med. Sci., 1940 - 18 : 343). A preliminary extraction of cobalt was made with nitroso-naphthol and chloroform, in earlier samples by the method of Beck (*ibid* 1945 - 23 : 311) and later by an unpublished method of Dewey and Marston.

In the compilation of the map, the following levels of liver cobalt, both for sheep and cows, were used:—0.10 p.p.m. and above, "normal," from 0.09 to 0.05 "moderate deficiency," and below 0.05 p.p.m. "severe deficiency." All values are on a dry weight basis, and, except in the case of livers which were obviously fatty, are not corrected for fat content. Except in the case of the Jindong Experimental Farm, from which some 20 samples were analysed, each circle or triangle represents a single liver sample. Unless supported by unequivocal clinical signs and response to cobalt feeding, figures for the livers of very young animals have not been used.

The results for the livers from Jindong are described by Bennetts, Beck and Harley (Aust. vet. J. 1948 - 24 : 237). No explanation can be given why clinical signs of cobalt deficiency were not observed in experimental animals. Similar results have been obtained from the Bramley Research Station where apparently normal cattle have shown very low levels of cobalt in the livers.

Few pastures have been analysed because of greater difficulties in the analytical methods. The results obtained, however, confirm the existence of cobalt deficiency. Five samples from the Jindong, Metricup, Cowaramup, region showed a mean value of 0.05 p.p.m. Co on dry matter (range 0.03 to 0.06 p.p.m.). Samples from two farms at Karridale gave values of 0.04 and 0.09 p.p.m. Three samples from Treeton (about 6 miles east of Cowaramup) gave values of 0.04, 0.03 and 0.12 p.p.m. Thirteen samples from the Bramley Research Station and a neighbouring farm showed a mean value of 0.03 p.p.m. with a range of from less than 0.01 p.p.m. to 0.07 p.p.m. Values of 0.10 p.p.m. and above are regarded as "normal" for pastures.

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GENERAL

AGRICULTURE IN THE BRITISH ECONOMY: Proceedings of the Conference on Agriculture in the British Economy, Brighton, Sussex, 1956. Lond., 1957.

FARMING ADVISORY SERVICES IN NORTH AMERICA: Report of a Mission to Canada and the United States of America, June and July 1955, Sponsored by the Nuffield Foundation. Lond., 1956.

HEDGES, SHELTERBELTS AND SCREENS; by A. D. C. Le Sueur. Lond., 1951.

A HISTORY OF SCOTTISH FARMING; by T. B. Franklin. Lond., 1952.

AN INTRODUCTION TO THE BOTANY OF TROPICAL CROPS; by L. S. Cobley. Lond., 1956.

MUSHROOM GROWING: A Practical Manual; by R. L. O. Jackson. Lond., 1950.

SOCIAL FACTORS IN SERRATED TUSSOCK CONTROL: A Study of Agricultural Extension; by H. Fallding. Syd., 1957.

THE STORAGE OF SEEDS FOR MAINTENANCE OF VIABILITY; by E. B. Owen, with a chapter on the Genetical Aspects of Seed Storage, by T. Ashton. Farnham Royal (Bucks.), 1956.

VEGETABLE CULTURE: A Study of the Growing of Vegetables in the Open; by K. H. Johnstone. Lond., 1948.

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FARM BOOK-KEEPING; by C. V. Dawe. Lond., 1952.

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THE AMERICAN OASIS: The Land and its Uses; by E. C. Higbee. N.Y., 1957.

FARM SOILS: Their Fertilisation and Management; by E. L. Worthen and S. R. Aldrich. 5th Ed. N.Y., 1956.

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THE PRACTICE OF SOIL CONSERVATION IN THE BRITISH COLONIAL EMPIRE; by Sir H. A. Tempany. Harpenden (Herts.), 1949.

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TRACE ELEMENTS IN HUMAN AND ANIMAL NUTRITION; by E. J. Underwood. N.Y., 1956.

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FIELD CROPS

OATS: Their Cultivation and Use from Ancient Times to the Present Day; by W. M. Findlay. Edin., 1956.

PRINCIPLES AND PRACTICE OF FIELD EXPERIMENTATION; by J. Wishart and H. G. Sanders. 2nd Ed. Farnham Royal (Bucks.), 1955.

[PROCEEDINGS OF] THE CONFERENCE OF CEREAL BREEDERS AND GENETICISTS—CEREAL AND HERBAGE PLANTS, Longerenong Agricultural College, Victoria, 1956. Melb., 1957.

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THE UNDERGROUND ORGANS OF HERBAGE GRASSES; by A. Troughton. Farnham Royals (Bucks.), 1957.

FRUIT GROWING

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FORESTRY

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MEAT INSPECTION IN AUSTRALIA; by F. V. Collins. Adel. [195].

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SHEEP-SHEARING EXPERTING; by L. D. Ryan. Syd., 1957.

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A SURVEY OF WHOLE MILK PRODUCERS FOR THE PERTH METROPOLITAN AREA, WESTERN AUSTRALIA; by H. P. Schapper. Perth [1956].

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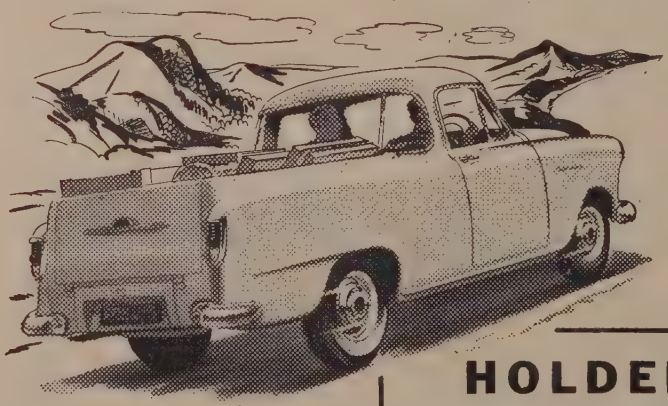

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Records Help in Controlling Infertility

By P. B. LEWIS, B.V.Sc., Senior Veterinary Officer

INFERTILITY in a dairy herd causes serious losses to the individual farmer and to the dairying industry in general. Obviously, the sooner an infertility problem is recognised the better chance we have of remedying the trouble. Unfortunately, many dairy-farmers do not realise that they have an infertility problem until it has reached very serious proportions.

By keeping a simple record of services, it is a fairly easy matter to determine whether a herd is giving the normal response to services, or whether it is showing definite signs of infertility troubles.

WHAT IS INFERTILITY?

If all the cows and bulls we are dealing with were absolutely perfect in every way —and the feeding and management were equally perfect—every cow should conceive to the first service and in due course should produce a calf.

However, there is no such thing as a perfect herd and we find that while a proportion of the cows will hold to the first service others in the herd may need two or three services to become stocked. How then can we determine whether our herd is reasonably normal or whether we have the beginning of an infertility problem?

CONCEPTION RATES

The Conception Rate or "C.R." as it is commonly referred to is **the percentage of cows holding to a particular service.**

At Artificial Insemination Centres for instance, the C.R. is usually calculated on the first, second and third services.

Suppose, for instance that we had 100 cows served on the same day, and 23 of them returned to service by or on the 21st day, then the C.R. for 21 days would be 100 minus 23 or 77 per cent.

By the time a month had passed, possibly three more cows would have returned so that the C.R. for one month would be 74 per cent. At the end of six weeks or two months, the C.R. may have dropped to 68 per cent.

As a rough guide, I would say that the normal C.R. would be somewhere around the following figures.—

One month after service—74 to 75 per cent. holding.

Two months after service—65 to 70 per cent. holding.

Three months after service—65 per cent. holding.

Broadly speaking therefore, about three-quarters of the herd should not show any signs of returning one month after the first service.

DON'T WASTE TIME

With these facts in your mind it should not be necessary to wait until cows have returned twice or more before deciding that you have an infertility problem.

It should not be necessary to wait until all the cows in the herd have been mated either. The first half of the herd to receive service will give you a reasonably good indication.

Take the 27-cow herd listed here. Between July 26 and August 2, the cows numbered 1 to 12 inclusive were mated.

	1st Service	2nd Service	3rd Service
1. Lulu	July 26		
2. Clara	„ 28	Aug. 22	Sept. 16
3. Strawberry	„ 28		
4. Roan	„ 28	Aug. 24	Sept. 15
5. Eva	„ 29	„ 27	
6. Ett	„ 29	..	
7. Madge	„ 31	Aug. 23	Sept. 16
8. Vera	Aug. 1	„ 29	„ 21
9. Daphne	„ 2	„ 22	„ 20
10. Creamy	„ 2	„ 25	„ 14
11. Lasho	„ 2	„ 27	
12. Topsy	„ 2	„ 29	Sept. 23
13. Darky	„ 3	„ 30	
14. Blue	„ 3	„ 31	
15. Bella	„ 3	„ 27	Sept. 24
16. Brownie	„ 4	„ 13	„ 24
17. Cherry	„ 5	Sept. 1	„ 26
18. Beauty	„ 5	„ 1	„ 29
19. Crumple	„ 7	Aug. 26	„ 18
20. Edie	„ 8	„ 30	„ 24
21. Thelma	„ 10	„ 29	
22. Red	„ 11	Sept. 10	
23. Spot	„ 11	....	
24. Smiths	„ 15	Sept. 3	Sept. 22
25. Clara's heifer	„ 16	„ 10	Oct. 19
26. Liz	„ 22	„ 13	
27. Betty	„ 23	„ 10	Oct. 3

By August 29 we know that all but three —Lulu, Strawberry and Ett—have returned to service. Three out of 12—one-quarter or 25 per cent, of the 12—have held to the service so our conception rate to the first service is well below normal, and it would be a wise move to call in veterinary assistance without delay.

By August 29 also we would know that Bella (August 27), Brownie (August 13), Crumple (August 26), and Thelma (August 29), had also failed to hold to the first service, thus confirming our diagnosis of an infertility problem.

KEEP RECORDS

By keeping a simple record of service dates as indicated it is an easy matter to check up on the C.R. of the herd.

Remember that about three-quarters of the herd should normally hold to the first service. If your figures are substantially below this, lose no time in obtaining expert advice.

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Pour the ARZEEN mixture—about 1 quart of solution per tree of 12 in. diameter is sufficient—into the frill, right around the tree.

IMPORTANT

1. Ensure the frill is level and as near to the ground as possible.
2. Apply the mixture with a utensil having a spout—i.e., an unwanted teapot.
3. The frill must run completely round the tree, with each cut overlapping.
4. Treated trees can be easily recognised if a little whiting is mixed with the solution before application.

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MANGANESE DEFICIENCY OF SUBTERRANEAN CLOVER IN WESTERN AUSTRALIA

By J. TOMS. B.Sc. (Agric.), Research Officer, Plant Research Division

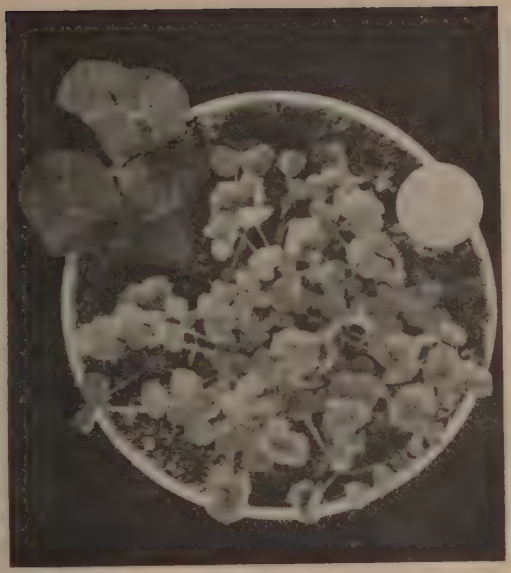

Fig. 1.—Manganese-deficient subterranean clover (Mt. Barker strain) compared with normal healthy leaf (left). The white disc is a threepenny-piece included to give comparisons in size

ALTHOUGH manganese deficiency is quite common on cereals in Western Australia, only recently has an extensive occurrence on subterranean clover been found. Compared with cereals, subterranean clover is evidently resistant to manganese deficiency. Even in areas where total death of cereal crops not receiving manganese fertiliser occurs, the undercover of subterranean clover generally grows quite satisfactorily.

Symptoms of the deficiency affecting subterranean clover were first noted in Western Australia at Esperance in 1952, and later at Denmark. In both these cases the deficiency occurred on land that had been limed, resulting in a more alkaline soil with corresponding fall in soil manganese availability.

Manganese-deficient subterranean clover occurring under normal paddock management was first observed at Bremer Bay in 1956. Little land development has occurred in this area, so the exent of the deficiency cannot be assessed.

The deficiency showed up on a variety of soils. Deep sands and sandy or gravelly surfaced soils overlying clay or sandy clay at variable depth are the types affected. The deficiency was noted on both Dwalganup and Mt. Barker strains of subterranean clover. An analysis of leaves and petioles of Dwalganup showed 7 parts per million manganese at flowering and an analysis of leaves and petioles of Mt. Barker showed 13 p.p.m. manganese shortly before full flowering.

In 1957 very small areas of manganese deficient Dwalganup subterranean clover were noted at Jerramungup (6 in. sand over clay) and at Wannamal (gravelly sand). The deficiency is not expected to be of economic importance in either of these districts.

DEFICIENCY SYMPTOMS

Plant growth is adversely affected early in the growing season. Particular leaf symptoms on the Dwalganup and Mt. Barker strains of clover differ to some extent.

The symptoms on Dwalganup are rather similar to those of potassium deficiency. Older leaves are first affected. Leaf colour changes from green to dull yellow-brown. Small spots of dead tissue occur over the

Fig. 2.—A normal leaf of Mt. Barker subterranean clover (top centre) with other leaves showing various stages of manganese deficiency

leaf surface but are collected mainly at leaf margins. These dead areas increase in size until scorching of leaf margins and eventual death of the whole leaf occurs. When the deficiency is mild, yellow-green leaves are produced, with leaf veins showing a deeper green. Seed production is greatly reduced but generally sufficient for regeneration.

In the Mt. Barker variety, plants showing mild deficiency develop a pale yellow-green colour and the leaves eventually show interveinal chlorosis. When the deficiency is acute, interveinal tissues of older leaves die, followed by complete death of the leaf. Plants at this stage are often very small and bright yellow with dead yellow-brown older leaves. Many plants die completely.

Some recovery often occurs with warmer spring weather but recovering plants still show interveinal chlorosis, and generally have brittle stems. Seed production is greatly reduced. The symptoms on Mt. Barker subterranean clover are generally similar to those of iron deficiency.

CONTROL

Production of clover was doubled by the application of 40 lb. of manganese sulphate per acre even though the plots were not fenced until a month before cutting, and prior to this the plots receiving manganese sulphate were preferentially grazed. It is probable that much lower rates of application will be sufficient to correct the deficiency as clover is not nearly as susceptible as cereals and 14 lb. of manganese sulphate per acre is generally used for cereals on manganese-deficient areas. In 1958 an experiment testing the immediate and residual effects of soil and spray dressings of manganese sulphate, will be commenced.

DEMONSTRATIONS SHOW THE VALUE OF FODDER CROPS

By F. E. RYAN, B.Sc. (Agric.), Agrostologist

DURING each summer season a series of demonstrations are arranged throughout dairying districts to show the value of fodder crops for extending the grazing period for dairy cows and to provide large quantities of suitable fodder during lean periods. Demonstrations are arranged with the co-operation of individual farmers.

The spring and summer season of 1956-57 was exceptionally dry and hot in most districts and the results obtained in these demonstrations are therefore of interest. There were a total of 19 demonstrations carried out of five types as follows:—

Maize and sorghum varieties for fodder.

Maize and sorghum varieties for grain.

Sudan grass, Japanese millet and sweet Sudan grass on summer moist areas.

Mangels and fodder beet.

Sudan grass on summer dry paddocks.

MAIZE AND SORGHUM FOR FODDER

As would be expected, this demonstration was severely influenced by the very dry conditions and good growth was obtained only in sections of paddocks which had retained their moisture a little longer than usual. Yields were generally low but some interesting results were recorded this year. Under good conditions of moisture throughout the summer and a high level of soil fertility Hickory King is usually more productive of fodder than the hybrid maize N.E.H.6 and D.S.28 which are somewhat earlier in maturity, but during last summer, these varieties tended to give better results than Hickory King because they had made their growth earlier before the onset of very droughty conditions. At Denmark the maize varieties in two demonstrations were placed in the order—N.E.H.6 D.S.28 and Hickory King, with Hickory King providing the lowest yield. Of the fodder sorghums, Italian sorghum was slightly better than saccaline sorghum at one site but the order was reversed at the second site.

At Busselton some yields were recorded. At Yoongarillup these were as follows:—

Hickory King—21 tons 4 cwt. per acre.

N.E.H.6—13 tons 13 cwt. per acre.

D.S.28—9 tons per acre.

Italian sorghum—19 tons 6 cwt. per acre.

Saccaline sorghum—10 tons 8 cwt. per acre.

These yields were not representative of the whole paddock but are of the moister sections. Generally the productivity of the various varieties was proportional to those figures above.

At Margaret River where drier conditions were experienced a very different set of yields were obtained as follows:—

N.E.H.6—10 tons 3 cwt. per acre.

D.S.28—9 tons 1 cwt. per acre.

Hickory King—7 tons 1 cwt. per acre.

Italian sorghum—5 tons 17 cwt. per acre.

Saccaline sorghum—5 tons 2 cwt. per acre.

It is obvious from these figures that in spite of the extremely dry conditions experienced, a considerable amount of fodder has been provided during the summer months for dairy cows.

MAIZE AND SORGHUM FOR GRAIN

Three demonstrations were sown but owing to the very dry season very little grain was formed. Under the droughty conditions experienced the sorghum varieties were found to be more drought resistant than the maize but even they were unable to produce very much seed because of the dry year.

SUDAN GRASS AND JAPANESE MILLET ON SUMMER-MOIST AREAS

Two demonstrations were carried out in the Busselton district incorporating commercial Sudan grass, sweet Sudan grass and Japanese millet. In spite of the dry season reasonably good results were obtained with these fodder crops.

At the first grazing which took place in January, crops had made good growth with slightly more bulk being obtained from the Japanese millet and least from sweet Sudan grass.

As the season progressed, commercial Sudan grass made most vigorous growth and recovered better following grazing. Recovery of Japanese millet was somewhat poor and the sweet Sudan grass was intermediate in production and recovery.

This demonstration has again shown that for bulk production in the early summer both Japanese millet and commercial Sudan grass are high producers but that under a grazing programme, Sudan grass is able to recover better after grazing and will produce for a longer period. In these demonstrations sweet Sudan grass was not so productive as commercial Sudan grass.

MANGELS AND FODDER BEET

Four demonstrations were arranged during the year to show the growth of mangels and fodder beet—two at Bunbury, one at Busselton and one in Denmark.

In one case germination was very poor and the demonstration was a failure but on three other sites, the demonstration was successful.

At Lowden, a yield of 15 tons per acre was estimated and the crop was fed off by stock during the late autumn and winter. The stock relished the beets which grew to a weight of 7 to 8 lb. In each case both tops and roots of the beets were eaten readily by stock. In some cases they were eaten on sites where they had been grown, without pulling.

This crop was shown to be valuable in the provision of fodder for stock in the late autumn and early winter period.

SUDAN GRASS ON AVERAGE PADDOCKS

This demonstration was arranged to show that Sudan grass could be used on paddocks which are not normally considered to be summer-moist providing they were ploughed up sufficiently early in the spring to conserve soil moisture. Six demonstrations were arranged in various districts and some excellent results were recorded.

At Lowden, estimates of yield were made at the time of the first grazing and it was considered approximately 13 tons per acre of green material were produced. This crop was grazed a second and a third time after the original estimates were taken. The Sudan grass planted on these paddocks showed outstanding drought tolerance and crops continued to grow right through the summer months and were still producing some leaf material in March and April.

An electric fence was used in most cases and the Sudan grass was strip-grazed. Some excellent grazing figures were obtained in various instances. Thus in one case it was estimated that the Sudan grass had a carrying capacity of 1 2/3rd cows per acre for six weeks. In another, 26 cows were carried for 27 days on 8 acres and after they were removed the Sudan grass recovered rapidly and made very vigorous growth for further grazings. In another case 22 cows were carried on 8 acres for 14 days at one grazing. At a second grazing they were fed one hour per day for 7 days and a third grazing the 22 cows were grazed for the full day and were carried for a further 7 days. Even after this grazing, further regrowth occurred and spasmodic grazing was continued.

The success of these demonstrations indicates quite clearly that Sudan grass is a very valuable crop for extending the green grazing period and therefore the lactation period of dairy cows.

VALUE OF THESE DEMONSTRATIONS

One of the most important factors in the production of butterfat per cow and consequently per acre is the length of lactation. In Western Australia the average lactation from dairy cows is too short for best results, but extending the lactation period of the cow also means that provision must be made for out of season grazing. To achieve this, summer fodder crops must be grown to extend the period when green feed is available. These demonstrations which are arranged in various districts are intended to show the value of the various crops for this purpose. It is obvious from the results obtained in 1956 that very substantial quantities of fodder can be obtained by this means.

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Meat Production

Some Impressions Resulting from the Recent Visit of Dr. John Hammond

By N. DAVENPORT, B.Sc. (Agric.),
Senior Adviser Meat Production

Fig. 1.—Dr. John Hammond

DR. JOHN HAMMOND, the eminent English authority on meat and meat production, commenced a two months' visit to Australia early in March, 1958, at the invitation of the Australian Meat Board. The object of this visit was to enquire into and make suggestions for the general improvement of our meat production in both quality and quantity. During his stay Dr. Hammond will visit the principal meat-producing areas of the Commonwealth.

Dr. Hammond commenced his itinerary by spending a week in this State. During that time he made a comprehensive tour of the meat-producing districts of the southern half of the agricultural areas and addressed groups of farmers at various centres including the Wokalup Research Station. In addition, conferences were held with research workers and with representatives of the meat trade.

As an example of what could be accomplished by the application of the results of research and improved husbandry practice, Dr. Hammond described the methods employed by the English farmer in making such a substantial increase in the home production of meat as has been accomplished since the commencement of World War II.

FERTILITY AND NUTRITION

Dr. Hammond stressed fertility and nutrition, with emphasis on the former, as being two very important factors for obtaining increased production.

With regard to fat lambs he considered it necessary to increase the fertility of our flocks, to the extent at least of obtaining a considerable percentage of twins. He pointed out that the rearing of twins resulted in a considerable reduction in the cost of rearing each lamb. At the same time it was obviously necessary for the ewe to be capable of providing sufficient milk for both lambs.

The inherent ability of the crossbred ewe to produce twins is almost wholly derived from its longwool ram sire, and

Dr. Hammond suggested that our stud-breeders could help to raise the fertility levels of our flocks by concentrating on producing these rams from animals which had the twinning tendency well-developed.

It is obvious that twin and triple births are essential to the English lamb-breeder. In this State however the necessity is not so pressing. We do not farm such high-priced land, nor are our pastures of such high carrying capacity. Also our ewes are not capable of the same level of milk production under present day conditions as the English fat lamb mothers. It is necessary for economic reasons to have half Merino blood in our crossbred ewes and the comparatively low level of milk production of the Merino limits the milking capacity of the crossbred.

That twins can usually be reared here more or less satisfactorily from crossbred ewes in a good season we already know. But for general application as a sheep-breeding policy it would appear necessary to improve the milking ability of those strains of the Merino which are suitable for mating to longwool rams for the production of crossbred mothers.

We require high-milking crossbred ewes and this character should be derived to the maximum from both sides of the breeding programme.

For the breeding of first-cross lambs i.e. using Merino mothers, twins are too often a liability and it is questionable whether—even with good management—it is sound practice to produce twins. At present farmers are concerned not so much in obtaining a high proportion of twins as in ensuring that all the ewes bear at least one lamb and that a high percentage of the lambs dropped survive to marketing. Neo-natal losses and subsequent deaths up to the time of sale or weaning are at the moment a serious limiting factor in flock production in this State.

There is evidence that this problem can be reduced to a reasonable level by improved flock management and the adoption of sound feeding and nutritional techniques both prior to, and after, lambing.

Dr. Hammond dealt with another aspect of fertility; that of increased lambing percentages through management of the ewe from well before mating until lambing time. He stressed the importance of keeping breeding ewes in lean store condition. Just prior to mating they should be "flushed" by putting them on better feed, or by supplementary rations, so that they tended to extrude more ova and give a higher percentage of twins.

In order to get the ewes sufficiently low in condition prior to mating, he suggested weaning all lambs at 10 to 12 weeks of age so that the ewes could be drafted off on to restricted grazing where they would not lay on fat as they would when sharing the good feed provided for the lambs.

This is a practice already followed by progressive farmers in this State and one that could well be adopted on a more general scale.

Mating, wherever possible, well into the breeding season was also recommended as a means of encouraging twinning.

The necessity for feeding the ewe well prior to lambing ("steaming up") was stressed by Dr. Hammond as a means of producing a strong healthy lamb with a good survival potential and at the same time ensuring a high milk yield from the ewe.

Although Dr. Hammond emphasised the the importance of "flushing" and its value is acknowledged with good flock management under our conditions at the present time, "steaming up" is a much more important aspect of husbandry for the breeding ewe. It is difficult to over-emphasise its importance.

Reference was made also to the English practice of mating ewe lambs at 8 to 10 months old. Providing they are well fed until two years old these ewes will develop satisfactorily although the initial lambing percentages will be somewhat lower than those of ewes mated at the normal age.

This practice is quite suited to our more favoured sheep districts and is in fact already being done by a number of farmers in the more southern lamb-producing areas. The principal advantage is that the breeding life of the ewe is extended, which is quite important economically.

Fig. 2.—At the Wokalup Research Station. Left to right—the Director of Agriculture (Mr. G. K. Baron Hay); Dr. John Hammond; the W.A Representative of the Australian Meat Board (Mr. B. Murphy); the Assistant Superintendent of Dairying (Mr. H. G. Elliott)

With regard to the conformation of the mother, Dr. Hammond said that the English breeder was not very concerned about it. What he wanted in his ewes was high fertility and milk production. The ram put the required conformation into the lamb.

This is broadly the position in New Zealand also. In both cases the lamb is of wholly British breed and therefore carcass conformation potential is high. In Australia however the mother is half Merino and therefore suffers in conformation, compared with a straight British breed. Conformation is thus a factor to be considered in our production of quality lambs in addition to fertility and milking ability.

BEEF PRODUCTION

Dr. Hammond dealt at some length with the great development which has occurred in the commercial beef cattle industry of the United Kingdom. The establishment of artificial insemination centres has been largely instrumental in effecting this. High quality beef bulls are used at all centres to inseminate dairy cows which are not required for breeding herd replacements. Aberdeen Angus and Hereford bulls are used, as these breeds "colour mark" their calves and are then visibly beef type animals. The Aberdeen Angus cross is polled and has a black coat and the Hereford cross shows the white face. The principal dairy breed is the Dairy Shorthorn and hence it would not be possible to use Beef Shorthorn bulls on such cows in view of the inability to determine by appearance whether the calves were of pure dairy strain.

Beef type bulls are in use at the artificial insemination centre of the Wokalup Research Station for a similar purpose.

When discussing the export trade in beef to the United Kingdom, Dr. Hammond explained that the market, after its own home-killed beef, prefers chilled (not frozen) carcasses with the minimum of fat, and weighing preferably 550 to 650 lb. The Australian Meat Board is fostering the production of this type of animal in Australia to the extent of allowing a bounty of 5d. per lb. for all such carcasses exported to the United Kingdom.

This trade is not acceptable to producers here, as at present the local demand can absorb most of our beef at higher prices than are obtainable in England. However should the present rapid increase in beef production in our agricultural areas continue it is likely that an export trade could be developed to cope with surplus production as with our lambs. Such quality carcasses suitable to the chiller trade are already being produced here.

With regard to the time of calving for beef production, Dr. Hammond explained that the calves are dropped a month or so before the feed comes away. The cow does not milk as well under these conditions and the very young calf can cope with the supply. When the pastures develop the calf is big enough to cope with the flush of milk. In this way troubles to the cow arising from the surplus milk and to the calf due to digestive upsets are avoided.

This is already a recognised practice throughout our beef-breeding districts. Many breeders are finding it suitable to calve as early as February, particularly if the cows have a high milk yield.

Meat production has now become a very important aspect of our agricultural economy. Meat in increasing quantities is required primarily at home for our rising population but also for export for feeding the outside world and what is also important for the establishment of overseas credits. We require not "just meat," but good quality meat. The home market as well as the export trade is keen in its demand for quality carcasses.

At such a time in the development of our meat industry the visit of Dr. Hammond is most opportune and will be of very considerable benefit to Australia.

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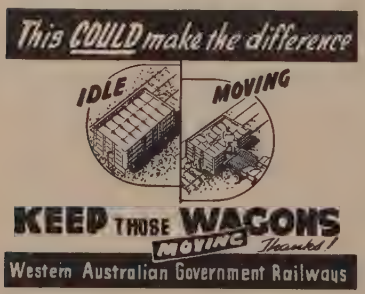

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WESTERN AUSTRALIAN GOVERNMENT RAILWAYS

Fig. 1.—Showing the native vegetation, consisting of a moderately dense stand of tamma scrub (Casuarina humilis), on the experimental area at Wongan Hills Research Station. The site was cleared and prepared for planting by ploughing up the standing scrub with a heavy disc implement, and scrub-raking twice to remove the debris

THE EFFECT OF SOIL FUNGICIDES AND FUMIGANTS ON THE GROWTH OF SUBTERRANEAN CLOVER ON NEW LIGHT LAND

By W. P. CASS SMITH, Government Plant Pathologist and A. A. HOLLAND, Plant Pathologist

SUMMARY

A SUBTERRANEAN clover establishment difficulty is described, which occurs on new scrubplain soils in Western Australia, and is caused by a widespread seedling mortality, associated with faulty nodulation. During an exploratory investigation conducted on a "problem" lateritic podsolic soil at Wongan Hills Research Station, the following preliminary results were obtained:—

1.—In unsterilised soil very poor establishment of subterranean clover was obtained due to faulty nodulation and heavy losses from seedling mortality.

2.—In soil sterilised with vapam and formaldehyde fumigants before planting an excellent stand of well-nodulated plants developed.

3.—Partial soil sterilisation resulting from the use of certain fertiliser-fungicide mixtures also promoted good establishment with adequate nodulation.

4.—It is concluded that seedling mortality of subterranean clover, as it occurs in this area, is caused by indigenous soil micro-organisms which prevent nodulation

1. INTRODUCTION

In Western Australia, extensive areas of sandy and gravelly "scrubplain" country, within a rainfall of approximately 14-25 inches, have been brought under cultivation in recent years. As these light lands are inherently low in fertility, they cannot sustain a permanent and payable agriculture until they are farmed on a legume-based rotation. After clearing, cereal cash crops must be limited and legume pastures established at an early developmental stage if humus impoverishment, followed inevitably by soil erosion, is to be avoided.

Subterranean clover has been utilised very largely for this purpose, but under certain conditions, great difficulty is often

experienced in establishing this ideal legume on these light soils.

This difficulty in establishment is caused by a widespread seedling mortality which is invariably associated with faulty nodulation. The seed germinates normally and healthy plant growth occurs for the first few weeks but, thereafter, numbers of seedlings become unthrifty and severely stunted. These affected seedlings have no nodules on the extensive and apparently healthy root system and they develop purplish red foliage in contrast with odd healthy well-nodulated plants which may occur in close proximity. The majority of these stunted plants die progressively, but a few become sparsely nodulated on the deeper roots and survive until the end of the season, but with little or no seed formation. Seedling losses are variable, but in some instances, they have amounted to almost 90 per cent.

Attempts to overcome this faulty nodulation by inoculation combined with various sowing methods have been unsuccessful. (Cass Smith, Harvey & Goss unpublished data).

Many forms of rhizobial inoculum have been tested, including seed inoculation with agar and peat cultures, seed-cleaning residues and soil from established subterranean clover stands. The seed has also been sown mixed with, or separated from superphosphate or basic superphosphate fertiliser, and has been both non-pelleted or pelleted with calcium carbonate or other materials. However, none of these treatments has brought about any marked improvement in nodulation, or significant reduction in seedling mortality.

Extensive nutritional trials have also been conducted in these areas but the results indicate that this difficulty in establishing subterranean clover is not caused basically by deficiencies of major or trace elements. (Dunne & Shier, personal communication).

Information concerning the occurrence of seedling mortality has been obtained from investigations related to the development of light lands in W.A. (Shier & Dunne, personal communication.)

It has been found that the seedling mortality problem becomes less significant as the soil ages under cultivation. It is most serious in sowings on newly-cleared, non-fallowed ground and, under these conditions, losses are generally so great that the stand is virtually a failure. On new ground which has been well fallowed after burning off the native scrub, or on ground which has been cultivated for a number of years, seedling mortality is usually much lower and, in normal seasons, a satisfactory establishment of well-nodulated plants may be expected. In those cases nodulation often occurs in the absence of inoculation.

As a result of these findings and observations it was concluded that the difficulty in establishing subterranean clover might be caused by indigenous soil micro-organisms. In order to test this hypothesis an exploratory experiment was designed to study the effect of soil sterilisation treatments on the first and second year growth of subterranean clover in a newly cleared scrubplain problem area. In this paper some preliminary first year results are reported which support this hypothesis.

2. MATERIALS AND METHODS

Soil Sterilisation with Fumigants.

Soil fumigants with a "wide spectrum" if used at high dosages would eradicate or greatly reduce the population of indigenous soil organisms. Furthermore, when applied at a pre-planting stage, they would not be injurious subsequently to the rhizobia introduced by seed inoculation, or to the host plant. They would therefore serve as a measure of the importance of soil micro-organisms in relation to this problem. *Vapam* (Sodium N-methyl dithio-carbamate) and *formaldehyde* were selected for this purpose.

Partial Soil Sterilisation with Fungicides.

Available fungicides, with few exceptions, are highly toxic to rhizobial bacteria but, if mixed with the fertiliser and sown without contact with, and beneath the inoculated seed, they might provide zones of partially sterilised soil with a reduced content of micro-organisms. This might enable the inoculating rhizobia to colonise these zones at a later stage and bring about nodulation.

After some preliminary tests the following fungicides were selected for trial

and used in mixtures with the basal fertiliser at two dosage levels.

Thiram (Tetramethyl thiuram disulphide) and *spergon,* syn. *tetroc,* (Tetrachloro-para-benzoquinone) at 2 lb. and 20 lb. per acre.

P.C.N.B. (Pentachloronitrobenzene) at 14 lb. and 28 lb. per acre of a proprietary 60 per cent. formulation.

Fig. 2.—Portion of the experimental plots showing layout and differences in the growth of subterranean clover due to treatment. Plots numbered 16 and 17 were fumigated before planting with formaldehyde and vapam respectively

In addition to these fungicides *calcium cyanamide* was also selected for trial. This material is not only a nitrogenous fertiliser but possesses fungicidal properties which bring about a partial sterilisation of the soil (Collings, 1955). A granular commercial product containing 21 per cent. nitrogen was used at a single dosage of 28 lb. per acre mixed with the basal fertiliser. To check the value of calcium cyanamide as a fungicide, rather than a fertiliser, a treatment was also included in which nitrate of soda was mixed with the basal fertiliser at the rate of 1 cwt. per acre.

Seed Pelleting.

In all treatments involving the use of mixtures of fungicide and basal fertiliser the inoculated seed was pelleted with calcium carbonate by the method devised by Cass Smith & Goss (1958).

This technique was applied with the object of delaying the movement of the rhizobia into the rhizosphere and thereby minimising the risk of injury from toxic fungicide residues.

Other Treatments.

A number of other treatments* were also tested but as they were ineffective in the first year they have not been listed in the table in this article or mentioned subsequently except as required for purposes of comparison.

3. FIELD EXPERIMENT DETAILS

Site.

An area was selected at the Wongan Hills Research Station, on the hardpan phase of the Elphin series (Smith, personal communication) of a lateritic podsolic soil. (Stephens, 1953.) On newly cleared soils of this series poor nodulation of subterranean clover and severe seedling mortality have occurred, but good clover pastures are obtained after cultivation and cereal cropping.

A simplified profile consists of 4 in. of grey, gravelly, loamy sand, pH 6.0 = 6.5 overlying 9 in. of gravelly, sandy loam usually grey-yellow. The native vegetation consists of a moderately dense stand of tamma scrub (*Casuarina humilis*) between 5 ft. to 7 ft. in height with bare ground below (see Fig. 1).

The experimental area was cleared and prepared during February and March, 1957, by ploughing up the native vegetation with a heavy disc implement, and scrub-raking twice to remove the debris.

The ground was cultivated to a maximum depth of three inches during these operations and, as a seed bed, was much inferior to those usually prepared by farmers.

* Seed treated with actidione; seed pelleted with calcium carbonate, calcium gluconate, and activated carbon, both with and without the addition of actidione; activated carbon @ 1 cwt. per acre (Hely *et al* 1957); nitrate of soda @ 1 cwt. per acre; pre-plant treatments comprising water drench, surface soil removal, and removal of organic matter by sieving.

Fig. 3.—Showing very poor establishment of subterranean clover planted by the standard method in unsterilised soil

Layout.

A randomised block layout with six replications of each treatment was used. Plot size was, 4 links x 4 links with buffers of similar area between plots (see Fig. 2).

Pre-planting Soil Fumigation.

Vapam and formaldehyde fumigants were applied to the appropriate plots on April 9 and 10, 1957. Vapam was used at a concentration equivalent to 435 lb. active ingredient per acre, and formaldehyde as a 2 per cent. solution of commercial formalin.

Each material after dilution with water was applied as a soil drench at the rate of three gallons per square foot. As a check on the effectiveness of these fumigants for soil sterilisation purposes, a drench of water only, was applied at the same rate to other plots.

Planting Details.

The plots were planted on May 28 and 29, 1957. Plantings were made in drills, each plot containing three drills, 4 links long x 1 link apart. The basal fertiliser consisted of zinc-copper superphosphate at the rate of 180 lb. per acre. Both basal fertiliser and fertiliser-fungicide mixtures were sown in the drills at a depth of 1½ in. Unsterilised subterranean clover seed var. Dwalganup, inoculated with a pure culture of rhizobial strain NA.30 was sown uniformly in each plot at the calculated rate of 5 lb. of viable seed per acre. Both inoculated seed and inoculated pelleted seed were planted at a depth of ¾ in. directly above the fertiliser.

The standard method of planting mentioned later, refers to inoculated seed planted above basal fertiliser.

Plant Counts.

Three counts were made during the season namely (1) on June 25, after the completion of germination, (2) on July 17, by which time considerable seedling mortality had occurred, (3) on September 30 and October 1 at the late flowering stage when counts were confined to established plants which had more or less formed runners and set some seed. In all cases (see Table) plant numbers have been expressed as a mean percentage of the viable seeds sown.

Sampling.

When the second and third counts were made, sample plants were taken for nodule examination. However, the number of healthy plants removed for this purpose was limited, as second year establishment data is also required.

Rainfall.

The monthly rainfall during the growing period, compared with the 31 year average shown in brackets, was as follows:—June 643 points (254), July 81 (260), August 202 (194), September 46 (91), October 41 (69).

4. RESULTS

Plant counts together with other data are shown in the table.

THE EFFECT OF PRE-PLANTING SOIL FUMIGATION AND FUNGICIDE/FERTILISER MIXTURES ON THE FIRST YEAR GROWTH AND ESTABLISHMENT OF SUBTERRANEAN CLOVER ON NEWLY CLEARED, NON-FALLOWED LIGHT LAND AT WONGAN HILLS RESEARCH STATION.

Treatment	Germination (June 25th) Percentage	Plant Nos. (July 17th) Percentage	Plant Establishment (late flowering stage)		Calculated plot yield (air dried wt. gms.)
			Percentage	Visual rating	
Vapam	89	83	82	excellent	1760
Formaldehyde	89	74	74	excellent	1512
Thiram—high dosage	84	70	67	good	656
Thiram—low dosage	82	53	41	poor	.
Spergon—high dosage	82	43	33	poor	
Spergon—low dosage	87	60	55	good	429
Calcium cyanamide	87	55	50	fair-good	157
P.C.N.B.—high dosage	82	43	26	poor	
P.C.N.B.—low dosage	89	60	33	poor-fair	
Standard method	88	20	14	very poor	

Following the heavy opening rains in June, a good and reasonably uniform germination occurred in all treatments. When germination counts were made on June 25, plants in the vapam and formaldehyde treatments were mostly at the second trifoliate leaf stage and they were more vigorous and had a darker green colour than the remainder. In all other treatments growth was somewhat less advanced and the cotyledons and first trifoliate leaves of most plants were developing the reddish tinge which is associated as a primary symptom with seedling mortality.

By July 17, when the second plant counts were made, the superiority of the vapam and formaldehyde treatments had become even more apparent. The plants in these plots were all healthy and vigorous and they were more advanced in growth than the remainder, runner formation being general.

Plots planted with the standard method had become inferior to all others. Seedling mortality losses were very high and even the plants which had survived were with few exceptions unthrifty.

Of the plots planted with fertiliser-fungicide mixtures, the *thiram* high dosage and *spergon* low dosage treatments appeared most promising at this stage. In these, seedling mortality losses were low, and numbers of plants with purplish red leaves were beginning to recover and form healthy runners. To a lesser extent recovery and runner formation were also noted in the *calcium cyanamide* and P.C.N.B. low dosage treatments.

On September 30 and October 1 when final plant establishment counts were made at the late flowering stage, each treatment was rated visually with plant size, density and ground cover as criteria. Yield data based on a limited number of plants sampled for nodule examination, were also obtained from treatments which were obviously more effective than the remainder (see Table).

Plots planted by the standard method proved a failure (Fig. 3). The plants in this treatment were so poorly nodulated that only a small percentage had survived, and even the established plants had set little seed, and were very sparsely nodulated on the deeper lateral roots.

In marked contrast the plots fumigated before planting with vapam and formaldehyde were outstanding, the ground being covered over with a dense mat of vigorous plants which had set seed abundantly (Figs. 2 and 4). Nodulation was excellent and was largely confined to the upper tap-root area.

Of the fertiliser-fungicide mixtures, three were obviously effective and superior to the remainder namely—thiram high dosage (Fig. 5) spergon low dosage and calcium cyanamide. In these treatments establishment was good and the plants had formed strong runners and set quantities of seed.

Fig. 4.—Showing excellent establishment of subterranean clover planted by the standard method in soil sterilised with vapam

The plants were nodulated on the tap and lateral roots, but at a deeper level than the plants in the fumigated plots, and the nodules appeared to be confined largely to a root zone in proximity to the fungicide placement area.

It is noteworthy that the check treatments comprising a pre-plant soil drench with water, and the addition of nitrate of soda to the basal fertiliser, gave poor results and, were respectively, greatly inferior to the soil fumigation and calcium cyanamide treatments.

5. DISCUSSION

It has been shown in this experiment that, despite the use of a tested rhizobial culture strain and adequate nutrients, subterranean clover planted by the standard method failed to establish because of seedling mortality losses, which were associated with poor nodulation.

By sterilising this soil with *vapam* and *formaldehyde* fumigants and planting under otherwise identical conditions, seedling mortality was eliminated and an excellent stand of well-nodulated plants was obtained.

These results provide strong evidence that seedling mortality as it occurs on this newly-cleared light land is caused by indigenous soil micro-organisms which prevent nodulation.

Although the seedling mortality problem is of considerable economic importance its solution by this means is impracticable and cheaper methods must be sought. Partial soil sterilisation, obtained by mixing appropriate fungicides with the basal fertiliser, would appear to have promising possibilities both for this purpose and, as a technique for the determination of problem areas.

The effectiveness of such fungicides would depend largely on their fungicidal value, phytotoxicity to host plant and rhizobia, and residual properties, which in turn would be influenced by dosage.

Specific differences were demonstrated in this experiment, *thiram* fungicide being more effective than *spergon* at high dosage (20 lb. per acre) whereas at low dosage (2 lb. per acre) the reverse was true.

Each of these materials at its better level promoted an establishment of subterranean clover which would be regarded as very satisfactory if the ground had been fallowed and planted by the standard method.

Calcium cyanamide (28 lb. per acre) also gave a satisfactory establishment apparently because of its fungicidal properties, and as this material is available elsewhere as a standard nitrogenous fertiliser, its use in mixtures with basal fertiliser should be widely tested.

Although specific micro-organisms which hinder nodulation in this new light soil have not been identified it seems probable that they inhabit the rhizosphere of the subterranean clover plant and affect the

Fig. 5.—Establishment of subterranean clover obtained by mixing thiram fungicide with the basal fertiliser at a dosage of 20 lb. per acre

rhizobia adversely, either directly by antagonism (using this term in the widest sense) or indirectly by an influence on the host plant.

The results obtained in this experiment lend some support to the findings of Hely *et al* (1957) who have shown by laboratory techniques that poor nodulation of subterranean clover on a yellow podsolic soil in N.S.W. is caused by microbiological antagonism which results in failure of seed inoculation.

6. ACKNOWLEDGMENTS

The authors gratefully acknowledge the co-operation of colleagues in the West Australian Department of Agriculture, particularly Dr. T. C. Dunne and Mr. F. L. Shier who supplied details of their nutritional and cultural experiments, and Mr. S. T. Smith who described the soil type and profile. Thanks are also given to Associate Professor J. M. Vincent, School of Agriculture, University of Sydney for providing a culture of NA.30. Supplies of P.C.N.B. and calcium cyanamide were kindly made available by Henry H. York and Co. Pty Ltd., and the American Cyanamid Co. respectively.

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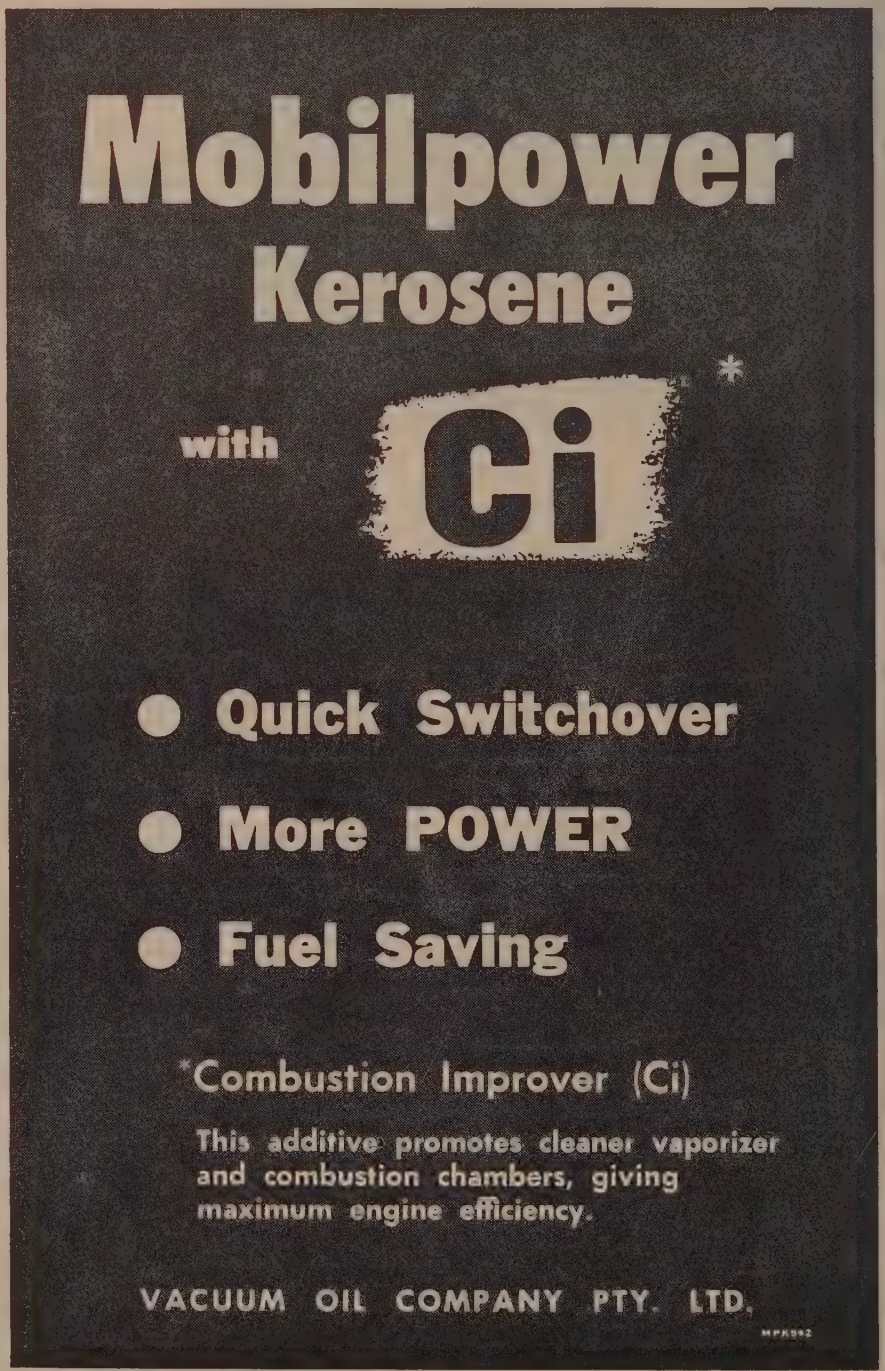
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WASTAGE IN WEANERS

By L. C. SNOOK, D.Sc., Animal Nutrition Officer

EVER since I can remember, the breeders of Merino sheep have been plagued with what is known as the "weaner problem." During the dry summer months, unthriftiness becomes apparent, the affected animals lose condition, and unless green feed becomes available a number will die. The losses on any one property are rarely devastating but over the years the collective wastage of young sheep has been, in some cases, considerable. A puzzling feature is that weaners will be lost on pasture which appears to be adequate for the grown sheep. Also the unthriftiness is often restricted to 10% or so of the weaners in any one flock. It is not uncommon to hear sheep men complain that while the bulk of their young sheep are thriving, there is a "tail" which "looks dreadful."

Many theories have been advanced to explain these sporadic and unpredictable losses. Naturally, the dry summer feed receives most of the blame. This is said to be lacking in protein, or vitamins, or some mineral essential for the well-being of young sheep. If this is so why is it that breeding ewes do not need the same vital nutrients? This query is countered by the argument that young sheep have not had time to build up reserves of vitamins, or that the weaners are much more susceptible to infestation with worms. If this is the case why do a goodly proportion of the weaners do well under the same conditions which are deadly to the unthrifty minority? And why are ram and wether weaners more often affected than ewe lambs? One could list many apparently puzzling features. In the absence of a reasonable explanation I have heard farmers assert that the young sheep become unthrifty from sheer cussedness.

SHORTAGE OF FOOD

My own explanation has been the simple one. Namely that the losses are due to a straightforward lack of food. This has been dismissed as being far too simple to explain a long-standing, supposedly complex problem. Nevertheless, recent research has confirmed this field observation. An observation, incidentally, which has been long recognised by the tip-top farmers who never have an unthrifty weaner.

ENSURE A GOOD MILK SUPPLY

The field conditions which precede unthriftiness in weaners are clear and straightforward. If sheep men understand these conditions the trouble can be avoided. First and foremost, it is essential that the ewes should be well fed so that they have a bountiful milk supply and can rear a robust, heavyweight lamb. It is the lightweight lamb from the ewe with

a poor milk supply which is most likely to become unthrifty. The late-born lamb which has to be weaned early in life is an equally likely subject. The importance of the ewe must be emphasised—weaner trouble begins with, and is generally confined to, those lambs which get a bad start in life. It is surprising that this obvious explanation has been so often overlooked. The affected lambs are those which were under-sized at birth or whose mothers could not give enough milk because of poor feeding, or a damaged udder. Naturally the lamb which is well-grown and vigorous at weaning time is much better equipped to tackle hard, dry feed than is his under-sized brother.

It should be emphasised that susceptibility to worms is determined to a large degree by the milk supply of the mother. In many experiments it has been shown that lambs receiving plenty of milk will thrive on worm-infested pastures on which underfed lambs will die. It is for this very reason that the outstanding fat lamb producers find it quite unnecessary to drench their sheep. Adequate nutrition is the basic safeguard. To provide this safeguard a capacity to produce plenty of milk is a basic essential in the breeding ewe.

HANDFEEDING WILL REDUCE LOSSES

Of course the story does not end here. If the weaners are to remain thrifty they must be well fed when taken off their mothers. Even the lightweight lambs which occur in most flocks can be carried through if given plenty of food.

As one would expect, young greenstuff is the best feed for weaners. Unfortunately, greenstuff of any kind is rarely available during the long summer months. Fortunately, excellent results can be obtained if other food is made available.

If possible the weaners should be placed in paddocks where a good growth of mixed pasture has been cut at the early flowering stage and left to lie. The cut material will be both palatable and nutritious, and the mown fields will be free of the grass-seeds which are such a menace to weaners. The feeding out of good quality meadow hay achieves the same purpose.

As the quality of the feed in the paddock declines, it is essential to feed a supplement of cereal grain. This supplement should be fed before the weaners start to fall away in condition. The talk of "cussedness" among sheep is not without justification. If the good feed is held in reserve too long, both weaners and pregnant ewes may refuse to eat when extra feed is made available.

A valuable series of trials have been carried out in South Austraila on dry paddock feed which would not support weaners. Without supplements the lightweight animals began to waste away and die within a month. But on similar feed no losses occurred in a group of weaners which were given oat grain twice a week at the rate of ½ lb. per head daily. The weaners receiving this grain supplement did little more than hold their body weight but none of them died.

A GRAIN SUPPLEMENT PAYS DIVIDENDS

Of more interest to me, however, is the performance of a third group which was supplied with oat grain in a self-feeder. The weaners in this group could eat all the grain they wanted and in fact consumed an average of 1½ lb. per head daily.

When fed at this rate for some months this requires a lot of grain. It may be argued that it would be better to sell the oats and risk a few deaths among the weaners. The extra grain, however, did a lot more than keep the young sheep alive. It produced bigger sheep carrying more wool. This extra development is of particular value to the young ewes. Well-grown ewe hoggets can be mated earlier and will give a lamb-drop every bit as good as the older ewes. The resultant increase in lambs will pay for the extra grain fed to the weaners. Once again, let me stress that all these benefits were obtained from the use of a grain supplement only. Despite the poor quality of the dry paddock feed there was no need to purchase protein as such, or vitamins, or magic mineral mixtures. All cereal grains, wheat, oats or barley, are equally effective. It is a matter of using the grain which is

most easily grown. More care, of course, has to be taken when wheat is first used, as this can be dangerous to hungry sheep.

To summarise. Unthriftiness in weaners can be prevented by good husbandry. First and foremost the ewes must be generously fed so that the lambs are well-developed at birth and receive plenty of milk right up to weaning. Secondly, plenty of nutritious food will ensure continued well-being after weaning. Green feed is the best foodstuff for young sheep but excellent results can be obtained on poor quality dry pasture by the provision of cereal grain, preferably in self feeders. The cost of the grain which is used will be repaid by freedom from deaths, increased wool yields and more rapid growth. Weaner ewes which have been well fed can be mated younger, and can be depended upon to give a good lamb drop. On other words, simple, honest, home-grown feed can be used to beat the "weaner problem."

THE IMPORTANCE OF WEED CONTROL in the VEGETABLE GARDEN

By W. KOOYMAN, Vegetable Instructor

I SUPPOSE every vegetable grower realises that to obtain satisfactory yields of high quality produce, control of weeds is of considerable importance. There are many reasons why weed control is important, however, as each crop has special problems and characteristics, time would be too short to give a detailed account of all aspects. An endeavour will be made in this talk to touch on some of the more important aspects of weed control.

Weeds are usually fast-growing plants, consuming large amounts of valuable nutrients and water during their growing period. Besides causing injury in this way to many crops, weeds often harbour diseases and pests and this aspect is as important as the competition for water, light and plant nutrients, although it does not appear as obvious.

Nomatodes, thrip, red spider and a number of other harmful insects feed and multiply on weeds, and it is usually unsatisfactory to apply control measures in the field when these pests can live and multiply in the vegetation nearby and invade the crop again and again.

Several weeds are known to be hosts of virus diseases and as a rule, these weeds do not produce the usual disease symptoms. The disorder is often readily transmitted by insects from the weeds to vegetable crops.

Most weeds will thrive on many types of soil and grow quickly under adverse conditions. They usually grow well on roadways, paths, near fences, walls and places where other plants could not exist and they often withstand droughts better than any other type of plant. Weeds are more easily controlled when they are small and every effort towards eradication should be made before they become too big and cause injury to the crop. The possibility of a rapid seed production is also a factor which should not be overlooked, and it is of considerable importance to prevent a "build up" of weeds on the property.

Weed control begins with the preparation of the soil before planting or sowing the crop. When preparing the soil, the grower should realise that vegetable seeds generally germinate more slowly than weed seeds and therefore, the soil should be cultivated thoroughly before planting, thus allowing the annual weeds in the top layer of soil to germinate. After germination, it is then possible to destroy most small weeds by way of a shallow cultivation and the crop can be planted or sown

in the comparatively clean layer of top soil. Therefore, good tillage is an excellent method of weed control and the prevention of weed propagation includes the destruction of weeds in the garden before they can germinate. Generally speaking, most vegetables are planted in rows which will permit the use of some sort of implement. The commercial grower often spaces his plants at such a distance that either horse-drawn or mechanically-drawn implements can be used. This aids control of weeds and reduces cost of production to a great extent.

Weed control in winter is often more difficult than in summer, as **weather** and **moisture** factors play an important part in keeping the crop free from weeds. Generally speaking, the sandy soils in the metropolitan area are easy to keep clean in comparison with peaty swamp, heavy loam or clay in country districts. Most sandy soils dry up quickly even during the winter months, whereas loam or clay may keep moist for many days. The clay particles will also stick to the fibrous roots, and often the weeds have to be removed entirely to prevent re-growth.

Next to good tillage and proper cultivation, vigorous plant growth will provide a certain amount of weed control because the ground will be covered quickly, thus smothering the weeds through lack of light. Complete eradication of weeds, however, is costly and only justified in exceptional cases, and generally speaking, the aim should be "weed control," meaning the reduction of weed infestation to such a degree that at no stage can injury to the crop be caused by weeds.

Chemical weed control is a modern development applicable to a limited number of vegetable crops. Because so much depends on the type of crop, the stage of growth and the weather at the time of application, chemicals may only be used by experienced growers, and it should be borne in mind that chemicals may cause serious crop injury when applied incorrectly.

The importance of weed control, both inside and, where possible, outside the boundary of the property, cannot be overemphasised. Better yields from better and healthier crops will always repay the cost of proper crop and soil management.

STRAWBERRY GROWING

By J. CRIPPS, Horticultural Adviser

STRAWBERRIES are not grown on a large scale commercially in this State, but many private growers cultivate them and indeed they are an ideal backyard fruit crop since they can be grown in a small area and are not subject to attacks by fruit fly.

The local commercial grower, recognising the importance of organic matter, normally grows strawberries in peaty soil. The private grower would be well advised to follow this lead and apply organic matter to the soil before planting strawberries. Cow manure, compost and lawn mowings are all suitable. Poultry manure from deep litter poultry, that is, poultry manure mixed with sawdust, could also be used. What is used will depend on availability, but whatever it is it must be used in large quantities. It would be very difficult to apply too much organic matter to soil which is to grow strawberries and experiments in other countries have shown that artificial fertilisers are no substitute for organic matter. It would also be advisable to mulch the strawberry bed with lawn-mowings at fairly frequent intervals and to give an artificial fertiliser such as Potato Manure E at flowering time.

The next step will be to procure planting material. Unfortunately vigorous strawberry plants free of virus diseases are difficult to obtain in this State. In other countries plants from virus-free clones, distributed from research stations, are grown in isolation by specialists. They

are sprayed frequently to control insect vectors such as aphids, and inspected by Government inspectors. Certificates are issued for virus-free plants and these are sold to fruit growers.

Locally the purchase of a virus-tolerant variety such at Climax is the only solution to the planting problem which I can suggest. This variety was recently introduced into Western Australia but it must be remembered that in its country of origin, Great Britain, it has become subject to a genetical breakdown known as June Yellows or streak. Although this trouble has not appeared here it may do so in the future and has, I believe, been noticed in Victoria. Therefore, although Climax is at present a suitable variety to plant locally, in a few years' time the situation may have changed somewhat.

Breeding programmes have been underway at two centres—Merton and Archincruive in the British Isles—and recently two promising varieties were released. It is hoped that these will have the virus-tolerance and resistance to red core of Climax, without the tendency to genetical breakdown.

If the grower desires to propagate his own plants, he should first of all select plants during the fruiting season for their vigour, cropping capacity and freedom from disease. These plants should be marked and then transplanted the following winter to a separate area as far away as possible from fruiting plants. During the next season frequent spraying with a systemic insecticide such as Metasystox should be carried out to kill the insect vectors of virus disease, and all blossom removed. Runners will of course be retained and planted out the following winter. In the case of plants grown for fruit, the reverse should be the case and all runners should be removed. The strawberry plant cannot produce both a good crop of vigorous runners and a large crop of fruit. Division of labour or functional specialisation is therefore essential.

When planting strawberries, great care should be taken to spread the roots, and planting with a dibber is not advisable unless the plants are very small. On a large scale planting, machines have given good results.

As regards planting distances in the row, 12 inches is the minimum, but in good soil a slightly greater distance is to be preferred. Distance between the rows will depend on the method of cultivation employed. Cultivation itself should always be shallow, as the strawberry is a surface-rooting plant.

When the crop appears, protection from slugs and snails will be necessary in the private garden and baits such as those containing metaldehyde should be put down. The application of a spray containing copper, such as Bordeaux mixture, to control leaf spot is also advisable.

Lastly, strawberries have a limited life and plants can only be expected to crop for two years so that the planting should not be regarded as permanent. A further area of soil should therefore be prepared and planted before the original plants reach the end of their economic life, that is, at least every two years. In no circumstances should replanting take place in an area recently occupied by strawberries.

To sum up, I would suggest that strawberries can only be grown successfully if healthy vigorous plants are obtained, organic matter added to the soil and either fruit or runners—but not both—produced.

KIMBERLEY RESEARCH STATION

A Progress Report, November, 1957

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Fig. 1.—The Ord River flows through this gorge in the Carr Boyd Ranges. The proposed dam site is in this area

KIMBERLEY RESEARCH STATION

A Progress Report

[Prepared by the Supervisory Committee of the Kimberley Research Station, November, 1957.]

INTRODUCTION

THE Kimberley Research Station was established in 1945 following upon proposals to dam the Ord River where it passes through a gorge in the Carr Boyd Ranges. Land reconnaissance and soil surveys indicate that an area of between 100,000 and 200,000 acres of potentially irrigable soils is available, which could possibly be utilised for intensive agricultural settlement.

The Station is 2,000 acres in area and is situated on the Ord River about 60 miles by road from the port of Wyndham on Cambridge Gulf in the far north-eastern portion of Western Australia. It is jointly operated by the Commonwealth Scientific and Industrial Research Organisation and the West Australian Department of Agriculture—the former assuming direction and control of the plant industry research programme and the latter providing station labour and management and assuming responsibility for research into soil and animal problems as the need arises in the development of the area.

The Station is concerned with agricultural investigations in the region and the immediate objectives of the research programme are to determine whether the soils are satisfactory for irrigation and

whether a stable system or agriculture could be developed to provide a sound basis for settlement.

These objectives and the results obtained from the early experiments were described in a report published in June, 1950 (J. Agric., W.A., *27;* 199-208). This report reviews progress since that time and presents certain conclusions based on results obtained at the Station.

The planning and supervision of experimental work has continued to be the responsibility of the Supervisory Committee, which was appointed in 1946,* but a further committee designated as the Kimberley Research Station Policy Committee was appointed in 1951, by agreement between the Prime Minister of the Commonwealth and the Premier of Western Australia. The functions of this second Committee in brief are:

(1) To review progress at the Station and to make recommendations for future work, including forecasts of expenditure involved.

(2) To recommend annual appropriation of funds.

(3) To report on the foregoing, through the appropriate Ministers, to the Commonwealth and State Governments.

This Committee consists of four members, two from Western Australia and one each from C.S.I.R.O. and the Ministry of National Development, representing the Commonwealth. The present constitution of the Committee is:

Mr. C. S. Christian—Chairman, C.S.I.R.O.

Mr. T. Plumb—Department of National Development.

Mr. W. M. Nunn—Department of Agriculture, Western Australia.

Mr. E. K. Steere—Public Works Department, Western Australia.

The research and extension staff at the Station this year include:

Director—L. C. Lee, C.S.I.R.O. (resigned May, 1957, successor to be appointed).

Technical Officer— E. C. B. Langfield, C.S.I.R.O.

Technical Officer—A. L. Chapman, C.S.I.R.O.

Technical Assistant—D. Beech, C.S.I.R.O.; G. Finn, Western Australia, Department of Agriculture.

Extension Staff—K. Fitzgerald, Western Australia, Department of Agriculture; J. Ritson, Western Australia, Department of Agriculture.

In addition, various officers of the Western Australian Department of Agriculture and the Division of Land Research and Regional Survey, C.S.I.R.O., have spent periods at the Station on specific problems.

An important factor influencing the Station's programme during the period under review was a recommendation by the Kimberley Development Committee of 1951* that crop areas on the Research Station should, where possible, be raised to an actual farm scale. In particular, that Committee recommended as a result of the examination of the position at that time, that rice and sugar cane be expanded in this way as soon as adequate planting material became available. The Station's Supervisory Committee, in accepting this recommendation agreed that "farm scale" might be interpreted as referring to areas of the order of 20 acres.

During the period covered by the first progress report of the Station (1946-50) some experience had been gained with a wide range of crops on the heavy-textured Cunnunurra clay soils of the Kimberley Research Station, and, with this information as a back-ground, the Supervisory Committee recommended that efforts should be concentrated, at least for the

* This committee consisted of:—
Chairman—C. S. Christian, C.S.I.R.O.
Executive Officer—W. M. Nunn, Officer-in-Charge, North-West Branch, Dept. of Agriculture of W.A.
G. H. Burvill—Chief Plant Research Officer, Dept. of Agriculture of W.A.
L. C. Snook—Animal Nutrition Officer, Dept. of Agriculture of W.A.
H. J. K. Gibsone—Officer-in-Charge, Irrigation, Dept. of Agriculture of W.A.

* This Committee consisted of—
G. Ruddock, Director, Division of Regional Development, Department of National Development.
P. A. Reid, for Director, Bureau of Agricultural Economics, Department of Commerce and Agriculture.
C. M. Dimond, Engineer, North-West Branch, Department of Public Works, Western Australia.
W. M. Nunn, Officer in Charge, North-West Branch, Department of Agriculture, Western Australia.

time being, on those cash crops which showed the most promise of forming a basis for agricultural settlement in the region. This recommendation was endorsed by the Policy Committee at its inaugural meeting in 1952, and has been the major principle in determining policy in the period under review. In the view of the several committees guiding the Station's policy, sugar cane and rice were the two crops showing most promise for development purposes.

II. SUGAR CANE

(a) Reasons for its Investigation.

Sugar cane was not mentioned in the 1950 Report on the Station, for it was not introduced into the Ord River region until June, 1950, when small quantities of 12 varieties of cane, selected by the Queensland Bureau of Sugar Experiment Stations on the basis of suitability for growing under irrigated conditions, were received from the Burdekin district of Queensland. In view of the general overproduction of sugar throughout the world, and the consequent restrictions on planting acreages, there have been certain questions as to the justification of the Station's policy of concentrating on sugar cane.

The justification arises mainly from the Report of the Royal Commission on the Sugar Industry in Queensland (1951) in in which it was forecast that as Australia's population rose, probable production in Queensland would fall below the estimated available markets to an increasing extent. An estimated deficit of 90,000 tons in 1962 was expected to increase to 167,000 tons by 1975. Western Australia's consumption of sugar in these two years was estimated to reach 44,000 and 52,000 tons respectively. The Committee was advised that the minimum mill size for economic production of raw sugar is about 45,000 tons per annum. The clay soils of the Ord River plains which could be immediately commanded by irrigation if a dam were built, cover about 40,000 acres. It appeared to the Committee that this compact area would provide for an efficient mill in the region, that Western Australia alone could absorb the major part, if not all, of the mill's output, and that on the basis of the Royal Commission's Report, the expected deficit between Queensland production and market requirements in the next decade could absorb the total output. A 45,000 ton mill would require about 10-12,000 acres in cane each year and this would utilise 50-70,000 ac. ft. of water annually on the farms. Allowing for distribution losses a dam supplying about 100,000 ac. ft. annually would suffice. For the minimum size mill therefore a relatively small engineering scheme would be required and such a scheme could well be regarded as a pilot scheme for larger irrigation development in the region.

Fig. 2.—An experimental plot of sugar cane

Other points in favour of a sugar industry are the nearness of the area to a deep-water port (Wyndham), the existence of an established shipping line between Wyndham and south, with a demand for back-loading, and the much shorter distance from Wyndham to the south of Western Australia than from Queensland, the present source of supply.

Apart from these arguments it is the responsibility of the Research Station from the long-term point of view to determine what forms of production are best adapted to the region irrespective of their immediate economic importance. The investigations so far have indicated that sugar is the best of the crops examined.

From the point of view of settlement, no crop better suited than cane could be imagined. With an assignment of 60 to

100 acres of cane per grower, there could be some 200 family units directly concerned with cane cultivation for one mill, plus perhaps double this number required for ancillary services, giving a very worthwhile concentration of permanent population in this very sparsely populated area of northern Australia. The gross annual income of the industry would reach several million pounds annually. If the whole of the available 40,000 acres was devoted to cane production these estimates of population would be more than doubled.

(b) Results of Investigations with Sugar Cane.*

The 1951-52 season was occupied by bulking up the original stocks of cane, and the experimental programme commenced in the following season. Sugar cane is normally grown on a ratooning system. Short pieces of cane, with three eyes or nodes, known as setts, are planted in the bottom of a furrow, which is filled in as the cane grows. The "plant cane" is harvested at about a year old by cutting off the canes at ground level. Shoots arise from the root mass, known as the stool, giving rise to a second year's crop of canes known as the first ratoon crop. These are cut at the end of the second year and the process can be repeated several times. In practice the crop of canes harvested each year diminishes, slowly on very fertile lands, but rapidly on infertile ones and at some stage it is no longer profitable to continue ratooning; the stools are ploughed out, and after a suitable period, the land is replanted with setts. Much of the commercial success of a cane planting is dependent on the length of the ratooning period, and few areas go beyond two ratoons. Two ratoons have been adopted as standard practice at the Kimberley Research Station during this early period. Experience has been varied: in some cases second ratoon yields have been only fair (20-25 tons per acre), whilst in other trials yields of between 40 and 50 tons of cane have been obtained.

Fig. 3.—Harvesting and weighing sugar cane

Yield levels (with 2 cwt. each of ammonium sulphate and superphosphate fertiliser per acre) have been good, and there are several records of a three year crop (plant cane + two ratoons) yielding over 100 tons of cane per acre. Table I summarises the yields of all crops up to and including 1956. It should be emphasised that these values include all varieties, both good and not so good, all crops, whether adequately fertilised or not, and all cultivations. With the knowledge now available concerning cultivation, varieties and fertilisers yields of 100-120 tons of cane for a three-year crop may be expected with some assurance.

The sugar content in the cane crops has been studied, by refractometer on expressed juice in the earlier years, and since 1954 by an actual calculation of extractable sugar following methods standardised in Queensland. These methods involve expression of juice from cane samples in an experimental three roller mill, and estimation of sugar in the expressed juice with the aid of a polarimeter. It has been found that sugar content is low at the end of the wet season, and that it rises sharply during the bright winter period, reaching a maximum about September. Renewed growth begins with the warmer spring weather, provided water is supplied, and sugar content falls: Early-cut canes may require as much as 10 tons of cane to produce a ton of sugar, whilst canes cut at the height of their sugar content may require as low as 6 tons of cane per ton of sugar.

* A full report on investigations with sugar has been prepared by L. C. Lee, formerly Director of the Kimberley Research Station, and A. L. Chapman, and will shortly be published.

Fertiliser trials have indicated that sugar cane responds markedly to ammonium sulphate in the presence of superphosphate, but not markedly to either of these fertilisers applied singly. Following the exploratory experiments, an annual dressing of 2 cwt. each of superphosphate and ammonium sulphate has been adopted as a standard, although there is considerable evidence to show that this is by no means optimum. Superphosphate can be replaced by ground rock phosphate. Preliminary trials indicate that over a crop of plant cane plus two ratoons, annual dressings of 4 cwt. of rock phosphate gave the same response as 1 cwt. of superphospate per year, but the differential residual effects of these fertilisers were not measured. Potash fertilisers have not given any response.

At least half of the dozen varieties originally introduced are of value in this new environment. Some varieties such as Pindar do well whether planted early or late, whilst others, e.g., Comus, succeed only when planted early. Some varieties, including Pindar and P.O.J. 2878, ratoon better than others; it is possible that these current varieties may be superseded by newer and still better ones (such as Q57) by the time commercial cultivation could begin in the Kimberleys, and therefore there is little point in studying complex variety fertiliser interactions at this stage.

Water usage has been examined both by soil measurements, by observations on leaf wilting and by measurement of cane elongation. During exceptionally hot dry weather such as may occur in November, irrigation may have been necessary at ten-day intervals, but in the cooler months the intervals may be as long as a month. In addition to rainfall, about 20 irrigations each of 3 in. may be required annually.

Table 1.

VARIETY YIELDS AND SUGAR CONTENTS—1951 to 1956.

Variety.	Classes of Cane.				Average Age (months)	Arithmetic Average of all Determinations			
	No. of Plant Crops.	1st Ratoons.	2nd Ratoons.	3rd Ratoons.		Tons cane/ acre.	C.C.S.	Tons Sugar/ acre.	Tons cane/ton sugar.
Pindar	9	7	4	1	12·8	39·90	13·00	5·04	7·74
P.O.J. 2878	4	3	1	1	13·3	36·28	14·71	5·89	6·86
Q. 50	2	1	1	0	12·5	34·10	14·33	4·57	7·03
Q. 57	3	1	0	0	13·0	36·74	12·43	4·89	8·03
Q. 28	2	2	1	1	11·8	30·57	15·05	5·02	6·70
Trojan	2	2	2	0	12·3	30·69	13·59	4·12	7·45
Comus	3	3	3	1	11·9	29·65	12·07	3·42	8·46
S.J. 4	2	2	1	1	11·8	27·32	13·63	4·45	7·40
S.J. 16	2	1	1	0	12·5	32·37	13·69	4·14	7·40
Badilla	2	2	1	1	11·8	24·93	14·32	4·09	7·03
S.J. 2	3	2	2	1	11·9	26·80	14·27	3·57	7·15
E.K. 28	3	2	2	1	11·9	26·80	14·05	3·56	7·18
H.Q. 426	4	3	2	1	13·0	18·86	14·74	2·54	6·84
Means	....	....	....	....	12·4	30·84	13·84	4·25	7·33

The only serious insect damage so far experienced with sugar cane has been an attack by a grasshopper plague from beyond the Station boundaries. This was met by spraying the cane with a BHC-diesolene solution from a mist blowing machine. No diseases of any consequence have been noted in the cane, and in particular, the virus which causes ratoon stunting has been up till now successfully excluded from the Kimberley Research Station.

(c) Conclusions and Comparisons.

The Committee is confident that sufficient experience and sufficient data have been gained with sugar cane to conclude that sugar cane is well adapted to the Ord River region, and to suggest that economic and social investigations are now of more

importance than continued agronomic investigation on the scale hitherto pursued. If a decision should be taken to produce cane commercially in this region, further agronomic investigations would then be justified and indeed essential to ensure the most economic level of production.

At this stage it is of interest to compare the experimental yields obtained at Kimberley with those obtained in other areas. The average yields for the period 1951-56, covering all trials, are given in Table 1. The yield levels now being obtained with the better varieties with the standard fertiliser dressing of 2 cwt. each of ammonium sulphate and superphosphate per annum are illustrated by those for a current experiment:—

	Plant Crop, 1956.				Ratoon Crop, 1957.	
Variety.	Tons cane/ acre.	C.C.S.	Tons sugar/ acre.	Tons cane/ ton sugar.	Tons cane/ acre.	
Pindar	46·7	12·6	5·91	7·9	43·0	Sugar
Q50	46·9	13·5	6·34	7·4	50·8	deter-
P.O.J. 2878	48·1	13·8	6·65	7·2	45·2	mina- tions
Q57	45·8	12·3	5·62	8·1	45·3	not
Mean	46·9	13·05	6·13	7·65	46·1	avail- able

The Lower Burdekin region of Queensland grows varieties included in the range of those grown at Kimberley, and has included mainly Trojan, Badilla, SJ16 and Pindar. The average annual yields for the 5-year period to 1955 were:—

	Tons cane/acre.	Tons sugar/acre.	Tons cane/ Ton sugar.
Lower Burdekin	34·5	5·05	6·84
All Queensland	24·0	3·26	7·35

These comparisons serve as a guide to the relative level of production possible in the Kimberleys. A strict comparison between the data should not be made as the Burdekin data are commercial production figures for a large area and the Kimberley data are from experimental plots.

The ratio of plants to ratoons for the Burdekin was 1 : 0.74 in 1954 and 1 : 0.78 in 1955. "Annual" values can however be somewhat misleading in that "plant" cane crops may occupy the land for somewhat over a year. The Kimberley results quoted above refer to a crop planted in June, 1955 and harvested in August, 1956 (plant crop) and in July, 1957 (ratoon crop). The soundest basis for comparison is sugar per acre per month of growing season. During the 1953 season (a record one for the area) sugar was produced on the Burdekin at the rate of 785 lb. per acre per month. The Kimberley trial quoted above was producing sugar at the rate of 980 lb. per acre per month. A time of planting experiment which included a plant and ratoon crop in a 24-month period produced sugar at the rate of 935 lb. per acre per month. The highest figure so far recorded at Kimberley is 1,300 lb. per acre per month.

It can safely be concluded that sugar production on the Ord River is at least on the same general level as that in the Burdekin region. This region is Queensland's outstanding producer, and since its yields are exceeded on a commercial scale only by the better areas of Hawaii, it can be concluded that the Ord River region seems ideally suited to sugar production.

From the agricultural production point of view it is established that with irrigation the Ord River region could carry an extensive sugar cane industry and that such an industry could support a greater farming community than exists anywhere in northern Australia at the present time outside the high rainfall eastern coastal strip of Queensland. A relatively small development of the sugar industry involving one mill in the Kimberley Division would give to the region a gross income of the order of £2,000,000 per annum. For comparison this is much greater than the annual payment to cattle stations by the Wyndham Meatworks.

III. RICE

The second crop with possibilities for the development of the region is rice. At the time of the previous report, all experimental work had been carried on with the only available commercial varieties from the Murrumbidgee Irrigation Area, mainly Caloro. It has been found that these varieties, and all similar Japonica types are unsuited to growth in the wet hot summer at the Kimberley Station. They do much better when grown in the cooler weather of May-October. Examination of a wide range of varieties imported from tropical countries has indicated some

Fig. 4.—A crop of rice grown under netting to protect it from birds. This method was used in the early stages of the experiments in order to obtain accurate yield figures

much better suited to the hot wet season. Some 350 varieties have been introduced from tropical countries—South America, Africa, India, Asia and Polynesia, and out of these, a range of types has been selected, all of which appear capable of good yields. The more promising varieties so far investigated include Emata-Yin and Hnan-wa-phin-gauh from Burma, Mas from Ceylon, Mbuyu, Moshi, Kohogo and Meli from Central Africa, Radin Siak from Malaya, Taichu 65 from Taiwan and a group of rices originating in the east (Japan) but developed in America, and further selected in N.S.W., of which Caloro is the best example.

One of the complications with rice is that there is not just one rice type, but a very wide range of types with differing qualities. The Station must study a range of types to determine which are the best marketable types suited for northern Australian production. A wide range of types is studied at the Research Station, for quality in rice may be defined quite simply as the desire of the purchaser. A soft rice which disintegrates on cooking may be top quality for some culinary purposes, but is unacceptable to most tropical peoples, who much prefer the harder flinty types which do not disintegrate on cooking.

Experimental yields approaching 4,000 lb. paddy per acre have been obtained with long-grain tropical varieties in the summer period, and with short-grain Japonica varieties in the winter. The tropical Indicas fail in winter, mainly through sterile heads, whilst the Japonicas give only poor yields of the order of 1,000 lb. per acre or less in the summer.

A bulk cropping trial in the 1955/56 summer period (November-April) gave the following yields:—

Variety.	Area.	Yield in lb. paddy per acre.
Meli	1·2 acres	4002
Radin Siak	3·5 acres	2285
Hnan-wa	1·7 acres	3323

Fig. 5.—Rice—Radin Siak variety—in one of the experimental plots

No comparable bulk data are available for dry season crops, but on experimental plots, yields of Caloro have reached 3950 lb.

The procedure for bulk cropping adopted as a result of experience in the Station is to sow rice seed into a prepared and pre-irrigated seed bed. Superphosphate may be drilled in with the seed, which is sown about an inch deep, while ammonium sulphate is placed as deeply below the seed as possible. At present the fertiliser is drilled in at 4 in. and the seed sown in a separate operation, but these could be combined with suitable equipment. The area is then irrigated and all surplus water drained away as quickly as possible. It has been found that the slightest ponding due to surface irregularities leads to a lowered stand and weakened seedlings, so that considerable attention is paid to the levelling of the area. An Australian-made Ashton Leveller is used for this. The bay is kept moist by irrigation, but no water is retained on the land until the rice is 5 to 6 in. high. It is then flooded and the water level raised slowly as the rice grows, until a depth of 4 to 6in. can be maintained by regular supplementation. This is drained off after flowering to enable the land to carry a header harvester some thirty days later. Experiments have been carried out to determine the optimum depth and duration of flooding, but the results are not yet sufficiently definite to recommend any departure from the procedures outlined above.

Estimates of the amount of water required by a rice crop vary considerably, depending on the season, on the variety which may require from 100 days to 200 days to mature, upon the cultural practices followed, and, with small bays, the amount of seepage. In general it may be reckoned that some five to six feet of irrigation water in addition to rainfall will be required for typical summer crops, and about three feet for short-term winter crops.

The main soil deficiencies are nitrogen and phosphorus, and growth in the absence of added fertiliser is very poor. Neither ammonium sulphate nor superphosphate alone has given a worthwhile response, but applied together marked responses have been obtained. From the experience available, the most satisfactory procedure would appear to be the application of 2 cwt. superphosphate plus 1 cwt. ammonium sulphate at planting with a further 1 cwt. of ammonium sulphate applied as a side-dressing when the crop is about six weeks old. It is obvious however, that there is still much to learn about the manuring of rice in this region.

Harvesting is carried out as soon as the grain can be stripped from the head. If left standing in the field, variations in the rate of drying give rise to fine cracks in the grains, leading to much breakage on milling. The relation between delay in harvesting and breakage on milling is shown in Table 2 (quoted from Langfield,* 1957). Harvesting at this early stage makes it essential to dry the grain under control before storage.

Birds have proved very troublesome at several stages of the crop. The small acreage of cultivated land in the region

* J. Aust. Inst. Agric. Sci. 23 : 340-341.

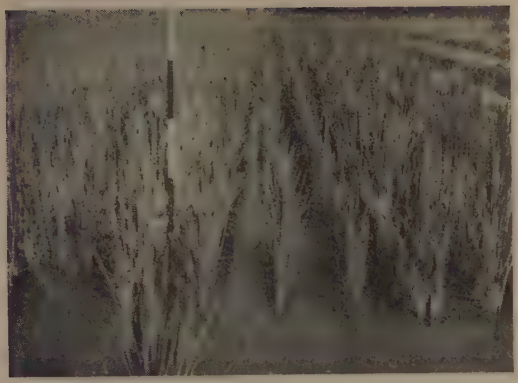

Fig. 6.—Portion of one of the rice trial plots

has no doubt exaggerated the problem, but there appears to be a natural hazard, which cannot be avoided, from finches at harvest time. Widely spaced crops, with clear water areas between the plant are particularly attractive to ducks. Larger drill-sown acreages, where the only open water expanses are in the edges of the field, are much less troubled by them. The finch trouble can be minimised by taking off the grain as soon as possible, for most of the damage caused by finches is from shattering of heads.

Table 2.

RICE.

Head yield from hand shelled samples.

Days from Flowering.	Moisture Percentage at Harvest.		Whole grain Percentage on Shelling.	
	Shive Pu.	Hnan-wa-phin-gauh.	Shive Pu.	Hnan-wa-phin-gauh.
28	20·8	26·2	99·0	99·4
29	19·9	25·5	97·2	96·1
30	18·2	25·6	83·1	93·3
31	17·2	22·3	83·9	91·2
32	17·8	23·1	84·2	92·8
33	16·6	21·8	83·7	89·8
35	16·2	16·7	82·0	89·0
37	16·0	15·5	81·1	77·6
39	11·8	13·0	78·2	61·9
42	11·6	11·5	52·0	41·0
45	11·1	11·3	41·0	40·0
58	11·1	....	40·3	....

Cutting of variety Shive Pu commenced on 7th May, 1956, and Hnan-wa-phin-gauh on 14th May, 1956.

Wet season crops have been subject to severe damage from a group of insects known as stem borers. The moth lays its eggs on the leaves of the plant, and on hatching, the larvae make their way to the stem, usually near the base, and bore their way into it. They then proceed to eat out the insides of the stem, causing it to die. This group of insects is widely distributed throughout the tropics, but, until the last year or so, no adequate control measure had been devised. The insects themselves are still confused taxonomically; it is known that there are at least two species, and maybe as many as four, present on the Ord. They are essentially summer pests, and are much less abundant in the cooler months. It has been found at Kimberley that the larvae can hibernate deep in the roots of rice stubble, through the cooler weather, and so carry over from one summer to the next. The moths are nocturnal and a record of their frequency has been obtained with light traps operating through the dark hours. It is known from these light trap catches that the presence of a very few moths can build up to a very heavy crop infestation, since each moth appears to be capable of laying several clusters of eggs, each cluster containing a large number of eggs. Inspection of the crops for egg masses has given information which fits in with the proportion of gravid to spent females caught in the light traps. For three summer periods an entomologist from the W.A. Department of Agriculture has been present on the Station studying the problem. The standard insecticides such as DDT and BHC kill a large percentage of the moths but leave a residual population sufficient to cause serious damage. Recent reports from overseas emphasise the effectiveness of one of the newest insecticides, endrin, and this insecticide is to be tested at the Station.

Rice can be grown in the region and there is every reason to believe that yields would compare favourably with those obtained in other tropical countries, although they might not be as high as the average yields in temperate regions of the Murrumbidgee Irrigation Area. Although the gross return from rice would certainly

Fig. 7.—Harvesting a rice crop

be very much less per acre than from sugar cane, processing plants would not be so costly, and it must therefore be regarded as one of the crops for development in the area.

IV. NATURAL HAZARDS IN RELATION TO GRAIN CROPS

When discussing rice, the hazards from finches at harvest time and from borers were stressed. Some of the grain crops have been found to be much more susceptible to birds and to insects than rice, and the prevalence and difficulty in control has markedly modified certain grain production programmes, notably with sorghum, maize and millet. These crops are not at present grown for grain because of the great difficulties met with in protecting small areas from birds (cockatoos in the case of sorghum and maize, and finches with millet). In addition, they are all very susceptible to locusts. With much larger areas of land under cultivation than at present, these hazards could diminish greatly, but should agricultural development be initiated, a continued examination of these biological problems would be a necessary scientific activity.

V. OTHER GRAINS

(a) Sorghum.

Early experiments demonstrated that this crop could be grown successfully, the best crops being those planted towards the end of the wet season, coming into head in late June or July. The highest yield has been recorded with the variety Caprock, but a number of other varieties, including Hegari, Kalo, Wheatland, Alpha and Martin were not far behind. The maximum recorded yield is 4,600 lb. per acre. Marked responses to phosphate have been recorded, 1 cwt. of superphosphate raising yield from 620 lb. to 1,940 lb. per acre in one trial. Trials on row spacings have shown that rows 1 ft. apart have given higher yields than those 2 ft. or 4 ft. apart. It is suspected that this difference may also be connected with differential watering, for although it was planned to use furrow irrigation in all cases, the narrow 1 ft. rows were in fact, flood irrigated, as it was found impossible to keep the narrow channel open. Attempts to grow sorghum in the dry season, with plantings from May onwards, have failed, the plants exhibiting a period of near-dormancy in the June-August period. Investigational work with sorghum as a grain crop has not been persisted with, owing to the great difficulty in protecting plots against birds, but it is being grown as a forage crop.

(b) Millets.

Several introduced millets have been grown successfully in the wet season, but not in the dry. As with sorghum, finch and locust damage have upset most trials, and they are now grown only as fodder crops.

(c) Maize.

This has been grown at all times of the year, but has never yielded as well as hoped. The best yields have not exceeded 1,000 lb. per acre, and the heads are normally very imperfectly filled. Like sorghum it is very susceptible to bird damage.

(d) Wheat, Oats and Barley.

These have all been grown as dry season crops. Yields have been very variable, and it appears that the general level of yield is determined by the weather conditions around flowering time. High temperatures appear to be associated with poor yields, and vice versa. The 1953 crop of Kondut wheat planted in early June with 1 cwt. super per acre yielded over 2,000 lb. per acre, but the following year's trial, planted about a fortnight later, gave only half the yield. A fertiliser trial showed a good response to superphosphate up to the 2 cwt. per acre level, with no further

response to higher applications, or to nitrogen added with the superphosphate. Gabo wheat, planted late in July, 1953, gave a very poor yield.

Ballidu oats planted in early June gave a very poor return. Beecher and Atlas barley planted at the same time as the oats also gave poor returns, the former (an early variety) giving some grain whilst the latter, a later variety, yielded hardly any.

Investigation with cereals has been retarded in the last two years, first because of water shortages resulting from reorganisation of the pumping plant and more recently from staff shortages, but will be resumed when conditions permit.

Wheat has required some 20 in. of irrigation water, and as the grain has been described as a very suitable wheat for the supply of flour for the breadmaking trade, there would seem to be a distinct possibility of wheat being a subsidiary economical "catch crop" for the region.

Wheat, oats and barley, in contrast with other grains, have so far been relatively immune from bird damage. There have been mild attacks from stem borers (a different species from those attacking rice) and there have also been mild outbreaks of aphids. On the whole, however, the crops have been relatively free from pests and diseases.

VI. COTTON

The previous report emphasised the need for suitable varieties of cotton for the special conditions of Kimberley Research Station. A wide range of cotton varieties representing the world's major cotton growing areas has been tested, but no varieties have emerged showing any greater promise than the Queensland-selected American types which were first tried.

The first difficulties associated with cotton growing appear to be entomological ones. The Kimberley region has a wide range of native Malvaceous plants including *Hibiscus* and *Sida* species and these act as host for a wide range of pests, both of the vegative plant and of the developing bolls. These include the rough boll worm, the pink boll worm, the cotton seed bug and cutworms. The leaf-eating pests can be controlled by frequent application of DDT-BHC mixture, but these insecticides have not controlled the boll pests. Preliminary tests with a newly developed insecticide, endrin, have given very encouraging results, and if this protection can be repeated over a number of seasons, the prospect for cotton investigations will be much more promising. A recently concluded trial with Miller, Acala and Oklohoma Triumph varieties gave an average yield of 2,200 lb. seed cotton per acre when protected by endrin. Cotton free from insect damage has been produced on the Station from plants sown towards the end of the wet season. Such plants make fair growth until the cooler months of the early dry season when there is a check, and growth is not resumed until the advent of warmer weather in late August or September. Flowering may commence about the end of September and the resulting bolls are generally free from insect damage. But with cotton which does not open until November, there is a great risk of damage by early rains, as well as great difficulties in harvesting. A further disability is the very poor quality of the lint produced at this time of the year.

The ideal timing of the crop would appear to have flowering commencing towards the end of the wet season when the risk of insecticide applications being washed off is diminished, and to have bolls opening in the early dry season, say May-July, when good weather conditions could be anticipated.

There is a fair prospect of cotton being the crop which will make development of the region possible. Yield of 1,000 lb. seed cotton per acre would bring in a return greater than any crop other than sugar cane, and such a yield level must be regarded as a very modest one for an irrigated area. The main difficulty so far experienced has been in pest control; but current work gives hope that endrin may give this essential control, and once this is established this would be a sound basis for renewed investigations.

VII. OTHER FIBRES

When the Station first commenced investigations there was a marked interest in jute and similar fibres, owing to the

high price of imported jute. As a consequence, considerable attention was paid to jute, and to substitute fibres such as kenaf and roselle. Over a three year period (1951-1954) jute gave an average yield of 10½ tons per acre with 5 per cent. fibre content. Comparable figures for the Bengal Province of India are 13 tons and 6 per cent. fibre. The quality of the fibre, as tested by C.S.I.R.O. Flax Research Station, was comparable only to second grade imported jute and fibre strength was "only just satisfactory" and was considerably lower than that of average Indian jute. One major disability with jute is that no satisfactory mechanical means of preparing fibre direct from the plant have yet been developed. In India the stems are "retted" with the aid of native labour.

A fibre which can be prepared mechanically—kenaf—has also been tested. Yields varied considerably from year to year and from variety to variety, but on average, were about twice those obtained with jute. The fibre produced was inferior to jute.

If the position should ever arise when it becomes urgent for Australia to produce its own fibres, both jute and kenaf could be produced in the Ord River region.

VIII. OILSEEDS

(a) Peanuts.

Peanuts have been a successful crop on the Station, as stated in the first report. They present particular problems both in harvesting and separating nuts from similar sized soil lumps. Investigations on peanuts have not been sustained because of these harvesting and sorting difficulties, which however, should not be mechanically insuperable. At present it does not seem that peanuts would be the cash crop to develop the area.

(b) Linseed.

Linseed was grown for three years as a dry season irrigated crop. Very erratic yields were obtained, ranging from virtual failures to half a ton per acre. Most of the difficulty of growing the crop occurs in the establishment phase, for the soil is ill-adapted to the preparation of the fine seed bed required for linseed. Bigger-seeded varieties have now been obtained and further trials are to be commenced.

(c) Safflower.

Safflower is a plant of the thistle family, and has been grown in the East from ancient time, where it has been raised both for oilseed production and for a yellow dye obtained from the flower. It produces an oil which in Australia sells competitively with linseed. Like linseed, yields have been erratic, ranging from

Fig. 8.—Safflower seedlings planted out

500 lb. to 3,000 lb. seed per acre, with an average oil content around 30 per cent. As a result of several seasons experience, it would appear that early plantings, which flower before temperatures begin to rise in late August or early September can give high yields, whilst late flowering leads to lower yields. It is hoped that yield levels may shortly be stabilised towards the high end of the observed range.

(d) Sunflowers.

These have been sown in both the wet and the dry season and also as an intermediate wet-dry season crop. In most cases, good plant stands have been obtained but there has been heavy mortality during growth. Imperfectly filled seed heads have also been common, with the net result that although some attractive looking crops have been obtained, yield levels, with a maximum around half a ton per acre, have been disappointing. Work

on sunflowers has been abandoned in favour of safflower, which appears to have much better prospects.

IX. PASTURES, FODDERS AND CATTLE

Grasses and legumes grew well at the first investigational centre on the Ord River—the Carlton Reach Station, which was sited on "red" soil (Ord sandy loam), but when investigations were transferred to the main soil type of the region, the black soil plains (Cunnunurra clay) very different results were obtained. This was especially marked in the case of legumes, and it is emphasised by the behaviour of legumes on the very limited areas of Ord sandy loam (red soil) along the river levee of the present Station when compared with the same legumes on the adjacent black clay. A wide range including various species of *Phaseolus, Stylosanthes, Centrosema, Calapagonium, Cajanus* and *Clitoria* grow well on the red soil, but of this wide range, only one, *Clitoria ternata* has persisted on the clay. All the legumes so far tried on the Station, with the single exception of *Clitoria,* appear susceptible in varying degrees to an insect transmitted virus disease of the "witch's broom" type. This virus appears to be much more damaging than its southern counterpart which attacks lucerne (*Medicago sativa*), for while witch's broom may take several years to severely damage a stand of lucerne in southern Australia, it can do so in a few months under Kimberley conditions. This virus or group of viruses is widespread amongst the native plants of the region, and does not confine its attacks to legumes. It has been discovered on grasses, cucumber and tomatoes.

Clitoria grows well under irrigation, and in pure stand may yield a total of about 3 tons of hay per acre per annum, taken off in three cuts during the dry season. It is very palatable and is relished by stock. It grows well with most grasses, especially the smaller clump grasses, such as fine-leaved Guinea. It is not well adapted to growing with the close sward forming grasses like certain Paspalums, nor can it compete with the giant Guinea grasses or *Pennisetums,* which may reach 10 ft. in height.

When grown in association with grasses, careful management is required to see that the pasture is not overgrazed, in which case the *Clitoria* is preferentially grazed and not given opportunity to reseed itself, nor yet undergrazed, when the *Clitoria* may smother out the grasses. The danger in the latter case is that heavy grazing of the pure *Clitoria* stand at a later stage may lead to a rapid increase of a number of unwanted low-value quickly establishing native grasses.

Grasses grown in close association with *Clitoria* in mixed pastures appear to obtain little, if any, benefit from the association, certainly nothing like the benefit associated with the clovers of temperate region. The general picture is that grasses do reasonably well when first established, but that they soon lose vigour. This loss of vigour is associated with nitrogen starvation, for the grass responds rapidly and markedly to the application of ammonium sulphate. This response is only transient, and when the grasses are again cut, there is no increased vigour in the regrowth. Investigations are still proceeding with this acute nitrogen starvation of pasture which occurs even in the presence of well-nodulated legumes, but attention has been shifted mainly to the production and conservation of cultivated forage crops.

The major growing season of the year is undoubtedly the wet summer period, and even with irrigation, many crops, including fodders which grow well in the summer period, show little or no growth in the cooler weather of the dry season. The summer period is the time when the native pastures are at their best, and when the need for supplementary fodder is at its lowest, consequently material grown at that time has to be conserved in some way, and the most obvious way of conserving wet season production would appear to be as silage.

In these trials, it has been clearly recognised that the nitrogen content of these black clay soils is low (0.03 per cent.), and that heavy continued cropping cannot be expected unless nitrogen is added liberally to the soil. The total nitrogen content of the 6in. surface layer of soil is of the order of 600 lb. per acre; a

five-ton fodder crop containing 12 per cent. protein would contain 220 lb. of nitrogen. It will be obvious that the soils could not produce such a crop for any length of time without liberal addition of nitrogen fertiliser. A trial now in progress using Elephant grass, receives 1 cwt. ammonium sulphate (or 23 lb. nitrogen) at each cutting. Cuttings are made when the grass has grown to a height of about 4 ft. and before any extensive development of woody stems has begun. In practice, about five such cuts can be made each year. With yields ranging between half and one ton of dry matter at each cutting, total yields of over three tons of dry matter per acre per annum have been recorded. The objective behind these trials is the production of palatable, high-protein fodder, which can be used to supplement bulk feeds of lower quality, and it has yet to be determined what minimum levels would represent economic production.

Studies have been made in the changes in weight of cattle maintained on native pastures. Yearling steers loaned by Ivanhoe Station were kept on native pastures throughout the dry season (May to December) at a stocking rate of 8 beasts to 100 acres. Each 100-acre paddock was provided with a watering point. In the wet season, the stock were released into a large holding area containing both red and black soil. Weight change followed the usual pattern in that there was rapid gain for about four months from the commencement of the wet season, and a weight gain of 200 lb. was registered in 100 days. This was followed by a period of slow gain up to the end of August and then a slight decline towards the end of the dry season. These Kimberley results differ from other northern Australian records in that the dry season loss was small (35 lb.), whereas much greater losses have been recorded elsewhere. When *Clitoria* hay of good quality (18 per cent. protein) was fed as a supplement there was a continued increase in weight in the dry season.

These supplementary feeding trials, with mineral amendments as well as with supplementary fodder, are still in the exploratory stages. Preliminary evidence indicates that good quality supplements can be produced either from heavily fertilised fodders or from the legume *Clitoria*, and that supplementary feeding of stock on native pastures towards the end of the dry season has distinctly beneficial results so far as live weights at the end of the dry season are concerned.

X. GENERAL MATTERS

(a) Rain-Grown Crops.

A number of crops have been tried under non-irrigated conditions in the wet season; in most cases over a period of at least two or three years, but such poor results were obtained in comparison with irrigated crops that further attempts were abandoned. Peanuts gave the best promise, but difficulties were met with in getting a good stand.

(b) Irrigation.

The use of plastic syphons to lead water from the main irrigation channel into the furrow has made irrigation much easier, and has permitted land to be used right up to the main channel. Syphons permit much better control of water application than the old system whereby a pipe let into the side of the channel fed water into a distributory system.

(c) Mechanical Properties of this Soil.

The "black clay" of the plains named Cununurra clay has in fact only 45.50 per cent. clay in the surface layer. Silt and fine sand make up most of the remainder. When dry the black soil cracks into massive blocks and in this condition requires considerable power to work. A Nuffield tractor (37 h.p.) is fully loaded in pulling a single rabbit-ripper tyne to a depth of 14 in. Working the land in the dry condition produces clods which weather down to give good structure. Wet working on the other hand leads to glazed surfaces which set hard and do not break down. When moist, the surface of the soil is very slippery and the passage of any wheeled vehicle is almost impossible. The Station now uses a track tractor (D4) for all heavy work and for work under wet conditions.

In spite of the high non-clay content of the soil, no difficulty has been experienced in constructing water-conducting channels which carry water, often at a level

of a foot or more above the surrounding country, with very little loss by seepage. The presence of a puddled layer on the surface of the channel appears to be the factor mainly responsible for this impermeability. In a similar manner no difficulty has been experienced in constructing water-retaining walls to rice bays. This impermeability of puddled soil contrasts with the ease with which irrigation water enters cultivated land. The usual application of 3 in. per acre can be applied to furrows a yard apart in a period of three to four hours.

(d) Minor Crops and Introductions.

In addition to work on major crops which could hasten development, the Station has built up a body of information on minor crops which could be of great use if development began. It is known, for instance, that a wide range of vegetables can be grown very successfully on the levee soils in the dry season, but that wet season production is difficult, being restricted to a few beans of Indian origin. Of all the species of citrus fruits so far tried—oranges, lemons, grapefruit and limes, only the last has shown much success. Bamboos have been introduced to help stabilise the river banks, but growth has not been encouraging. Mangoes and coconuts have suffered severely from white ants. Bananas are restricted by nematodes, but can be grown in family gardens with care. A number of ornamental trees have been established, including the Saman (rain tree) poincianas, various species of cassia, lemon-scented gum, and forms of bougainvillea.

One section of the Station's activities is apt to pass unnoticed except on those occasions when success is attained. This is the matter of introductions. Each year, a very wide range of introductions from other parts of Australia and from the world at large, is tried on the Station. Apart from rices, emphasis in recent years has been on legumes and grasses. The legumes include forage and pasture species, shrub species for browse, and crop species for cultivation, both as green manures and as cash crops.

It sometimes happens that species showing promise have to be eliminated on other grounds. Thus Spineless Mimosa Moisa showed promise on the black soils but was eliminated because of the possibility of reversion to the dreaded spiny types.

A usual occurrence is for an introduction to show marked variation from plant to plant when first sown. A few of these may show decided promise, but invariably the progeny of these promising plants has not shown much success in the following seasons. Soya bean has shown this tendency to a marked degree.

XI. AN ASSESSMENT OF AGRICULTURAL POTENTIAL OF ORD RIVER PLAINS

The results of experimental work conducted at Kimberley are largely applicable to similar land types found throughout the northern part of Australia, outside the narrow confines of the Ord River region. The Kimberley Research Station Policy Committee has fully recognised this fact, giving the wider aspects of the Station's work increasing attention in planning the research programmes. Nevertheless, the immediate objective of this work is to determine the suitability of the clay soils of the region for irrigation agriculture, and to develop a farming system which could provide the basis for the settlement of the area. Considerable progress has been made in fulfilling these objectives.

Although the climate of the region (Table 3) is not ideal for Europeans and may affect their working efficiency, it is certainly not unbearable, and not worse than in other parts of the world supporting successful and contented European communities. The winter climate of the area is pleasant and nights are cool throughout most of the year. The freedom from frost and seasonally high mean temperatures make the region suitable for a range of tropical and sub-tropical crops. Winds of damaging force, hail-storms and rain-storms of very high intensity are very rare. On the other hand, unreliability of rainfall and the limited length of rainy seasons make irrigation a prerequisite for successful crop production. Perennial crops cannot be produced without irrigation, and the risk of drought makes precarious even the cultivation of annual crops grown in the wet season. Fortunately the Ord River provides an ample

Table 3
CLIMATIC AVERAGES—KIMBERLEY RESEARCH STATION

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept. + Oct.	Nov.	Dec.	Year.
Rainfall—Points	734	709	506	65	22	18	7	3	8	78	268	498	Total 2916
No. of Wet Days	12	9	7	1	1	0	0	0	0	2	5	9	Total 48
Evaporation in inches	8·265	7·129	8·155	7·894	7·903	7·192	7·465	8·286	9·995	11·302	9·541	8·995	Total 102·122
Temperature in °F.—Maximum	97·6	95·6	97·5	94·8	91·5	86·7	87·1	91·0	96·4	102·2	101·7	99·5	Av. 95·05
Minimum	74·8	74·9	73·2	74·7	62·8	60·3	57·8	59·9	66·2	72·3	76·0	76·0	Av. 69·09
Relative Humidity at 9 a.m.—per cent.	63	65	55	42	32	33	31	30	32	39	47	53	Av. 44

and reliable source of irrigation water. The topography of the area is well suited to gravity irrigation. From the engineering design point of view the gentle slopes of the plains should make distribution and application of water a relatively simple matter. With the exception of levee land along the river, the erosion problem is not serious. The major part of the plains is usually free from natural flooding.

The cultivation of the heavy clay soils of the area requires skill, powerful tractors and sturdy implements. When wet these soils are extremely plastic and sticky. They dry out slowly, but when dry they become very hard. Although they do not present any insoluble mechanical problems, the possibilities of improving ways and means of their cultivation are considerable and further work in this field is well worth while.

The soil itself, as distinct from the land surface, does not drain freely, and waterlogging after rain imposes some limits on the range of crops which can be successfully grown on these soils. Because of the impermeability of the soil sub-surface, drainage measures would be both very difficult and expensive.

The physical characteristics of the clays make the plains impassable for vehicular traffic when they are thoroughly wet. Even track vehicles become immobilised in thick, sticky mud. The provision of suitable access roads would be essential for the development of this region. The swelling capacity of these soils would increase the cost of construction and maintenance of sealed roads.

The results of Kimberley manurial trials show conclusively that the black soils of this region, like many other tropical soils, are deficient in phosphorus and nitrogen. Moreover up till now, none of the legumes tried at Kimberley has shown the nitrogen-fixing qualities comparable with the clovers of temperate zones. The legumes tried appeared to be self-sufficient in nitrogen but did not benefit succeeding crops or the associated pasture grasses to any marked degree. Consequently the development of any form of agriculture suitable for the area must largely depend on the comparative returns from fertiliser application to various crops.

The experimental work at Kimberley has already indicated a range of promising crops for local conditions, and several crops have been successfully grown on farm-scale areas. These could provide the basis for a variety of farming systems. However, before such systems are tested on a pilot farm-scale a thorough study of economic and organisational aspects of agricultural production in the region is desirable.

Sugar cane appears to be at present the most promising crop, giving uniform stands and uniformly high yields. The economic and organisational difficulties of its introduction on a commercial scale in present conditions have been already mentioned. Rice has given very promising yields, although some nutritional problems are still largely unsolved. Its future in this area will largely depend on economic factors. Of other cereals only sorghum at present is agronomically promising, and the economics of its production as a main crop are doubtful. If the effectiveness of

recently tried insecticides is proven and high cotton yields can be maintained, this crop may become the backbone of local agriculture together with oil crops, especially safflower. In the absence of a biological source of cheap nitrogen, the special production of pastures and fodders for stock is more dependent on the use of artificial fertilisers and does not appear to be so promising as in the temperate, clover-growing regions. However, some of the crops showing promise at Kimberley, such as cotton and oil seeds, would provide also a useful source of protein concentrates.

Both sugar cane and rice are often grown in monoculture, and it appears at present that the system would have to be seriously considered for Kimberley conditions if these crops form the basis of development. On the other hand cotton and safflower might well be grown in a rotation, the former being planted towards the end of the year and harvested in June-July, the latter occupying the land from April-May to October. The short fallow during the wet summer months would replenish soil moisture supplies and reduce irrigation water requirements.

Except in the case of cotton where insecticidal control is still new, it is possible to give some estimate of what yields could be expected from the various crops mentioned above. It now remains for other specialist groups interested in development to ascertain whether such yields offer sufficient promise to form the basis for the planned development of the region.

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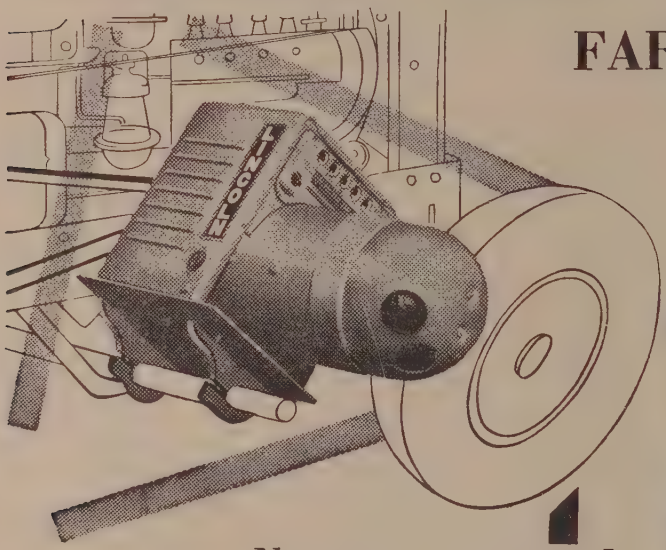

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Fig. 1.—Tomato gardens at Geraldton

WINTER TOMATO PRODUCTION

Problems Affecting the Geraldton Industry

(A brief review of research work carried out during the 1957 winter season in connection with fruit quality.)

By D. A. JOHNSTON, B.Sc. (Agric.), Agricultural Adviser

THE export markets of Melbourne and Singapore are the lifeblood of the Geraldton tomato industry. Local demand from Perth is insufficient to support the present industry. For this reason, growers are anxious to know the factors influencing the quality of their fruit on export markets.

Geraldton, because of its mild winter and favourable situation, can grow tomatoes during winter months when production in the metropolitan area and South-West of the State is curtailed due to the incidence of frost. The need for glasshouse production of tomatoes in Western Australia is thereby obviated as adequate supplies of tomatoes are available on the local market throughout the year. Supplies of Geraldton tomatoes surplus to local requirements are marketed in Melbourne and Singapore.

In order to comply with Victorian regulations relating to the introduction of fruit fly, tomatoes exported to Melbourne must be picked to arrive on the Melbourne market in a green condition. This and the fact that the fruit must undergo the hardships of a journey of almost 2,000-miles, including several trans-shipments, makes it difficult to land the fruit on the Melbourne market at a stage which permits it to be in prime condition after ripening.

Fig. 2.—A typical Geraldton tomato crop showing flood irrigation channels

In some years, heavy losses have been exeprienced by growers due to breakdown of fruit after leaving Geraldton. During the period May to August, 1957, an investigation was carried out of factors considered to be affecting the outturn of fruit on the Melbourne market.

This investigation covered such factors as climate, mechanical injuiry due to handling, mineral deficiency, diseases etc. During the investigation, temperatures were recorded at three locations in the tomato-growing areas. Fruit samples were taken from a large number of properties and stored under conditions simulating those to which export fruit consigned to Melbourne would be likely to be subjected. The following is a brief discussion of the findings of each of the aspects of the industry investigated.

CLIMATE

Tomatoes are subject to injury if exposed to consistently low temperatures for any length of time. Fruit chilling can occur where the temperature remains below 60° F. for 95 hours or more per week. The degree of damage increases with the number of hours over 95 experienced. The likelihood of damage occuring to fruit at Geraldton may be seen from a study of the following data:—

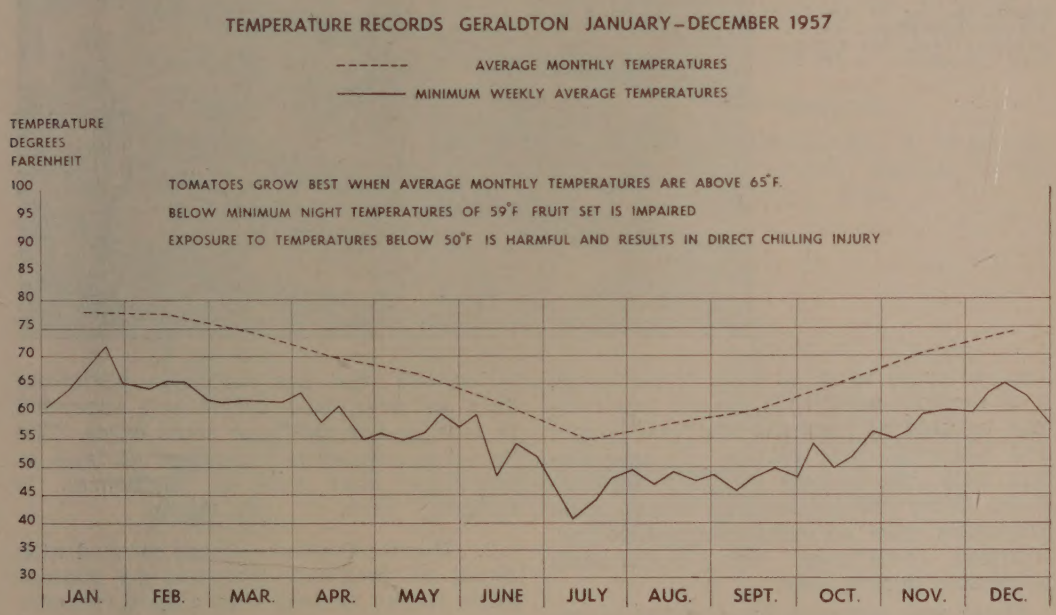
HOURS BELOW 60°F. PER WEEK.
Geraldton District, 1957.

Week ending Monday 1200 hours.	Thermograph Location.		
	Airport.	Utakarra.	Waggrakine.
June 3rd	49¾	66	*
10th	19¾	39¼	*
17th	99	107¾	*
24th	91	104	82½+
July 1st	95	112	68¼+
8th	122½	116¼	*
15th	129	126½	*
22nd	123¼	122	*
29th	118¼	114	94¾
Aug. 5th	119¼	115½	110½
12th	114½	115½	102
19th	99¾	114½	84¾

* Not available.

These figures show that during June, July and August, tomato crops were subjected to severe temperature conditions. The fact that damage due to chilling occurred during this period is borne out by the reports of poor outturns in Melbourne of fruit picked at this time.

shelves. All bags used should be clean and free from sand grains, since these small grains can injure the skin of the tomato fruit. At regular intervals, picking buckets and all parts of grading machines or benches coming into contact with fruit should be disinfected. At all



MECHANICAL INJURY

From the observation of stored fruit samples, evidence was obtained that a big percentage of fruit wastage is due initially to some form of mechanical injury. Bruising is by far the most serious factor. Skin cracking and lesions are also important. The injured fruit are naturally more susceptible to Early Blight infection, and attack by other storage rot fungi. Large fruit showed a greater incidence of bruising and injury than fruit of smaller size. Any methods adopted to reduce injury would considerably benefit quality and prolong the storage life of the fruit.

It is recommended that bags be placed in picking-tins and on the receiving-boxes to reduce damage during picking. On grading tables, edges should be well padded with sponge rubber, and extra bags or other padding placed on grading

times fruit should be handled carefully. Even very green fruit is subject to handling injury.

It is realised that damage must be incurred during transport of the fruit to Melbourne, a factor beyond the control of the grower. However, injury incurred prior to packing can be so severe that, as demonstrated by the storage of fruit samples, even neglecting transport damage, fruit could be almost unusable upon removal from the Melbourne ripening rooms.

MINERAL DEFICIENCIES

During the winter months a general potash deficiency was noted in practically all fruit samples. The heavy rainfall experienced in June 1957, resulted in increased fertiliser leaching, and during this period insufficient fertiliser was ap-

Fig. 3.—Methods of ripening fruit on open shelves and in polythene bags. The storage room temperature is 65° F.

plied to crops to make good these losses. It is recommended that potash topdressings be used at frequent intervals during and following wet weather, in conjunction with the normal fertiliser applications. Other deficiencies recorded on some properties were phosphate and nitrogen. Nitrogen deficiency was particularly noticeable during July.

There was evidence from visual symptoms that some minor element deficiencies are occurring in the three major tomato-growing districts. Deficiencies of manganese, boron and iron are suspected.

RAINFALL

The distribution of rainfall during 1957 caused several problems which could not easily be overcome.

Dry conditions prevailed until the end of May, and many crops were slow to develop. Heavy rains during June stimulated growth, but favoured also the rapid build-up of Early Blight (Black Spot). Fertiliser leaching was severe and these effects persisted during July when most harmful results were recorded.

GENERAL FACTORS INFLUENCING FRUIT QUALITY

1. **Storage Life.**—Under open shelf storage the life of the tomato fruit samples was approximately three weeks. When the fruit are sealed in polythene bags however, this period was extended to four or five weeks in some cases. The time lapse between harvesting of fruit at Geraldton and sale in Melbourne is normally three to four weeks.

2. **Disease Control.**—Crops sprayed with Zineb at frequent intervals to combat Early Blight, showed that a good measure of control is possible. It was noted on several occasions that fruit with fresh spray residues present were more resistant to the development of Black Spot or other storage rot fungi. This is of practical interest to the growers since it would appear that spraying of the fruit prior to packing could reduce the amount of fruit wastage due to disease. Dusts did not appear as effective as sprays for this purpose.

FRUIT MATURITY

It is difficult to lay down precise standards for maturity for picking purposes. Many growers are quick to realise that weather conditions during the tomato season play an important part in the development of the fruit and the time required for it to mature. Prior to July, fruit consigned could be greener than that forwarded in July and early August, with greener fruit again being required after

mid August. Later picking during July would give growers a better opportunity of selecting fruit for quality, and would reduce the time required in the Melbourne ripening rooms.

ACKNOWLEDGMENTS

The assistance of the Regional Adviser, Mr. G. Throssel, and the Horticultural Inspector, Mr. F. Herbert, is greatly appreciated. Without their aid the research could not have been so readily undertaken. Thanks are due to the Government Plant Pathologist for the identification of pathogens on fruit samples.

Appreciation is expressed to Mr. A. Devlin of the Geraldton Tomato Growers' Association and Messrs. Adams and Howell for their wholehearted support. All growers who supplied fruit samples and data of their cultural practices are thanked. For much of the temperature data, appreciation is extended to the meteorologists at Geraldton and Perth.

The Superintendent of Horticulture, Department of Agriculture, Victoria, for inspection reports on tomatoes upon arrival at Melbourne.

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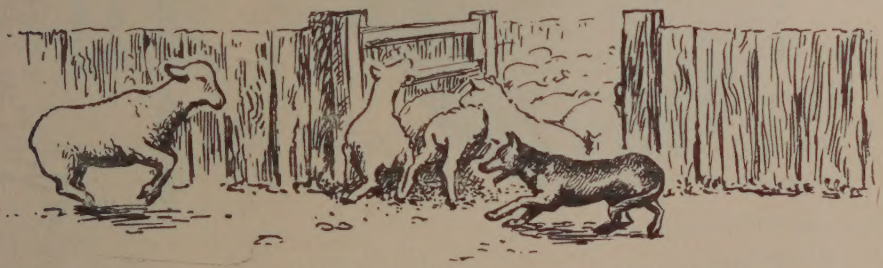

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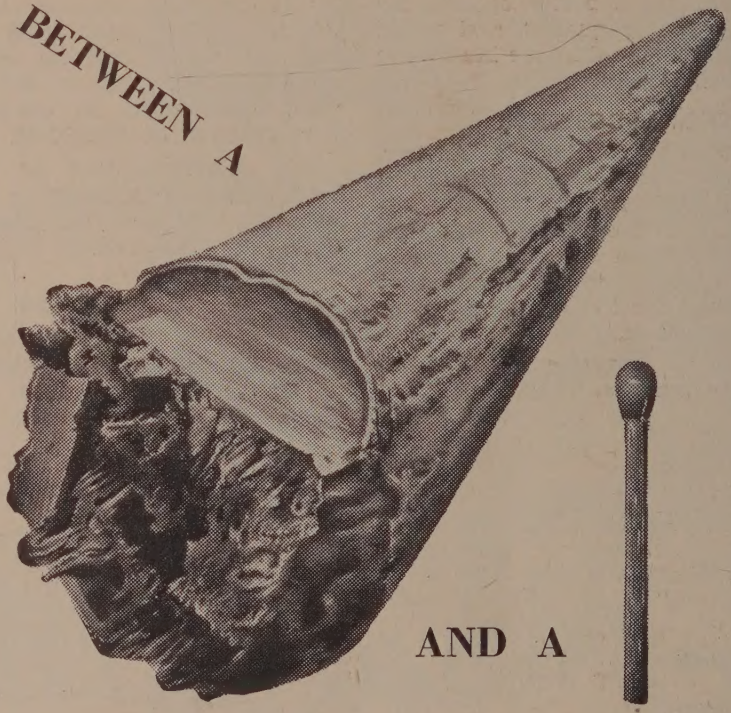

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